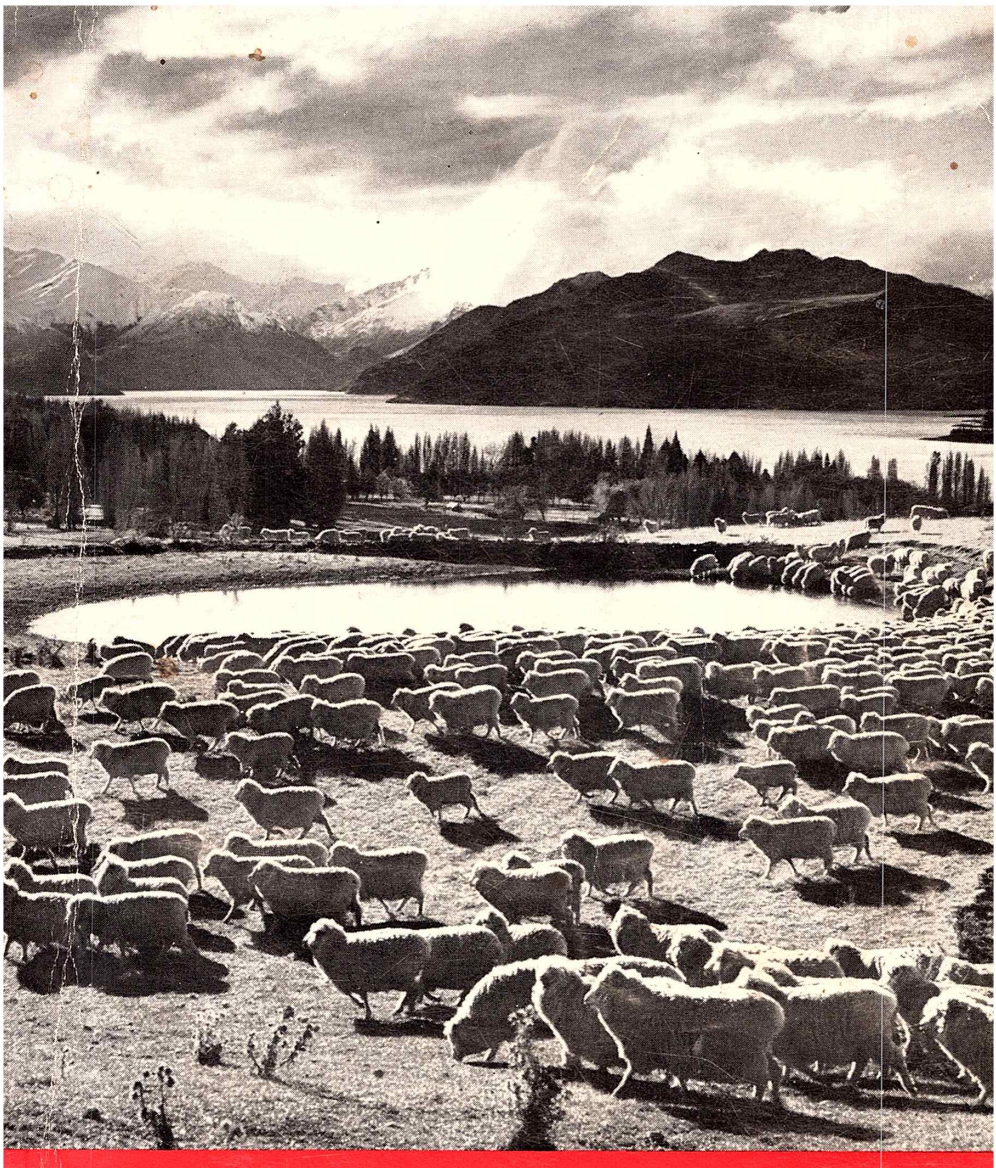

SHEEPFARMING ANNUAL 1961

MASSEY AGRICULTURAL COLLEGE
(University of New Zealand)

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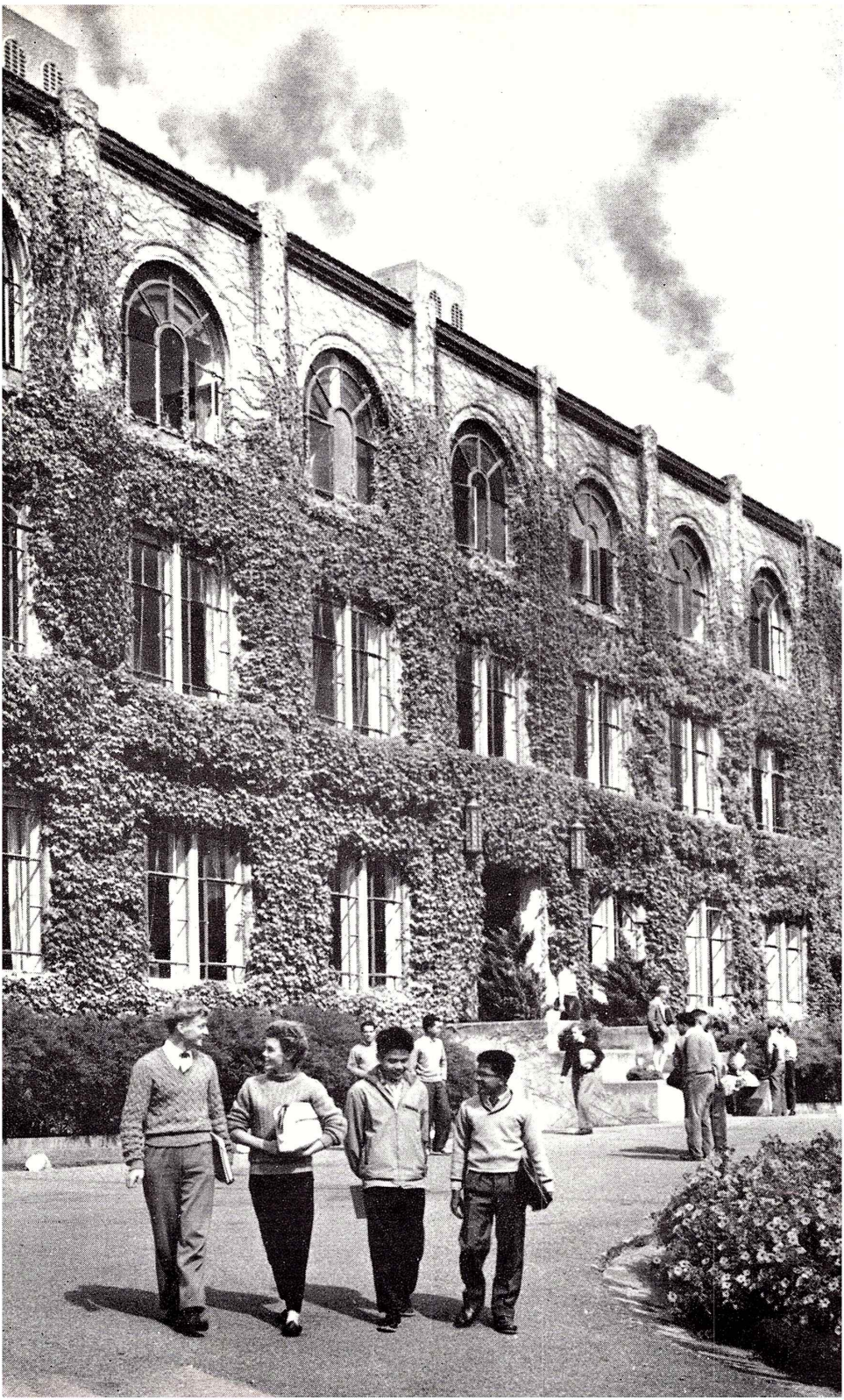
SHEEPFARMING ANNUAL

1961



SHEEPFARMING ANNUAL 1961

Including the Proceedings of the Twenty-fourth Annual Meeting of Sheep Farmers conducted by Massey Agricultural College, Palmerston North, on June 27-29, 1961

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OVERSEAS TRADE IN PRIMARY PRODUCTS

HON. J. R. MARSHALL*

Importance of External Trade to New Zealand and Dependence on Agriculture for Export Income

EXTERNAL TRADE is of major importance to New Zealand where the value of trade per head of population (£234) is one of the highest figures in the world. New Zealand has substantial import requirements and, with the high level of internal demand and the growth in industrial expansion that is taking place, the present high level of imports must grow. Payment for these has to be made from export earnings and, if this expansion is to be maintained, the fundamental objective of trade policy is to maximize export earnings.

**Deputy Prime Minister and Minister of Overseas Trade.*

New Zealand is at present faced with balance of payments problems, and restrictions on imports are still required. It is not Government policy to retain these any longer than necessary, and increased export earnings would assist greatly in remedying the position. However, changing conditions of international trade, fluctuations in prices for primary products while import prices continue to rise, and agricultural protectionism in many markets, have given rise to serious problems for New Zealand.

New Zealand's export trade amounts to about £300 million each year. The dependence on export income from agricultural exports can be fully appreciated when it is seen that in 1960 wool accounted for 34 per cent. of this trade, dairy products 26 per cent., meat 26 per cent., and other products such as tallow, hides and skins, and seeds about 6 per cent. In all, these items account for over 90 per cent. of New Zealand's total exports—a pattern which is traditional and likely to continue for many years.

New Zealand's Broad Trade Policy

Broadly speaking, New Zealand's trading policy is to buy and sell on world markets to the best advantage without attempting to offset exports against imports of any particular country. Though this policy is firmly based on the multilateralism of the General Agreement on Tariffs and Trade (GATT), bilateral agreements have been concluded as found advantageous. In addition to the long standing preferential trade agreements with the United Kingdom, Australia, and Canada, which are of overwhelming importance, New Zealand has had for many years most-favoured-nation agreements with Argentina, China, Spain, Egypt (all under former United Kingdom treaties) and Switzerland (partial most-favoured-nation treatment only). In recent years agreements have been negotiated with Japan, Western Germany, Yugoslavia, and Malaya.

Without going into all the undertakings New Zealand has obtained under these agreements, some brief comments might be made on those commitments of interest to farmers.

GATT

Since over 90 per cent. of New Zealand's trade is with GATT countries, the importance of this Agreement to New Zealand is obvious. GATT rules are intended to eliminate barriers impeding the expansion of international trade and therefore the Agreement

benefits New Zealand to the extent these rules achieve their objective.

Unfortunately, GATT has been less successful in reducing the barriers to trade in agricultural products than in industrial products but it does provide a body to which members can carry complaints about trade policies of other members.

It is likely that, without GATT, trade in agricultural products would have suffered even greater impediments than do exist at present, and New Zealand and other agricultural exporters are maintaining continued pressure in GATT and in other international bodies to improve conditions of trade for primary products. Some success is being achieved.

Under agreements with the United Kingdom (the 1959 Trade Agreement and the Meat Agreement of 1952) New Zealand is assured of duty-free entry for all its main export items, and is guaranteed margins of preference on certain goods, notably dairy products, casein, and sausage casings. In addition, the United Kingdom has undertaken not to impose quantitative restrictions on New Zealand butter, cheese, skim and buttermilk powder, casein, and meat before 1967.

Under the Agreements with both Australia and Canada, New Zealand is accorded either British preferential tariff treatment or special rates of duty on exports.

Under the Agreement with Western Germany, New Zealand has the right to sell up to specific tonnages of meat and to export up to specific values of grass seeds, blood meal, and dried blood and meat extract.

The Agreement on Commerce between Japan and New Zealand provides for unconditional most-favoured-nation treatment. In addition, Japan gave specific commitments on exchange allocation for wool, meat, tallow, hides, casein and dairy products which ensure access to the Japanese market, and also agreed, subject to certain reservations regarding wool, not to increase the duties on meat and wool imported from New Zealand during the period of the Agreement.

The Malaya/New Zealand Agreement, in addition to providing for reciprocal British preferential tariff treatment, guarantees duty-free entry for meat and tallow. It also binds the existing rates of duty and margins of preference on certain dairy products.

In the other agreements which New Zealand has, there is provision for the extension of most-favoured-nation treatment to New Zealand goods.

It will be appreciated that the Government has been active in securing opportunities for New Zealand trade to expand. There is increasing need for Government intervention in these matters as a way has to be found over or through the trade barriers associated with policies of agricultural protectionism in most of the industrialized countries. In addition, it is the policy of the Government to maintain a close liaison with the producers' organizations on all aspects of New Zealand's trade problems.

Survey of New Zealand's Trade in Primary Products for 1960

A full survey of New Zealand's trade in primary products during 1960 would take some time and as this paper is intended for sheep farmers it is proposed to comment in particular on those products of particular interest to them—meat and wool.

The total value of New Zealand's external trade in 1960 was the highest yet recorded. Imports increased by nearly £47 million over the relatively low 1959 level, while exports reached a record £302 million, an increase of nearly £9 million over 1959, the previous highest year. The main factors in this increase were rises of about £13 million and £4 million in the value of exports of wool and meat respectively, offset by a decrease of about £10 million in the value of exports of dairy produce.

Over recent years, there has been a steady overall increase in the volume of exports of the four main export commodities—wool, meat, butter, and cheese. However, exports of butter and cheese showed a fall in 1960, contributing factors being slightly lower production, the timing of shipping and the need to hold stocks in store in New Zealand in order to support the falling United Kingdom market towards the end of 1960.

It is evident that an increased volume of exports does not necessarily result in a corresponding increase in export realizations. Values for meat exports have been relatively stable, though with a unit return declining since 1957; but the unit returns for wool, butter and cheese have fluctuated sharply from year to year—and indeed, especially for butter, from month to month.

Wool

As in previous years, the United Kingdom was New Zealand's main market in 1960, taking wool valued at £30 million or 34 per cent. of exports of wool by value. France with purchases of £16 million was the next largest buyer, followed closely by the United States of America with £14 million. Other substantial buyers included Western Germany, Belgium, Italy, and Japan, while the U.S.S.R. and Poland resumed normal buying after relatively light purchases in 1959.

Total exports of wool by value in 1960 were £102·3 million, compared with £89·5 million in 1959, representing an increase from 30·5 per cent. to 33·8 per cent. of the total value of exports.

Wool is a raw material for a manufacturing industry. This industry, the manufacture of woollen textiles, carpets, and industrial felts, is carried on in most countries of the world. On the other hand, the production of wool is best undertaken in a temperate climate, and consequently only the temperate regions produce large quantities of wool. Moreover, within the temperate regions only the less densely populated countries have adequate land to support a large sheep population. The market for wool is therefore virtually world-wide, with relatively few countries producing large quantities for export.

The main uncertanties regarding wool marketing derive from its importance as an industrial raw material. The demand for wool, of course, reflects the demand for woollen products; this in turn is related to the general economic situation in the major industrial countries. This accounts for the fact that the sale of an increased quantity of New Zealand wool in a particular year can, nevertheless, bring in smaller receipts.

Exports of wool to the United States have been assisted since 1958 by the temporary suspension of import duty on wools of counts up to 46's for making carpets and other similar uses. The United States Government last year decided to exempt these wools permanently from the payment of duty. The assurance of duty-free entry is particularly valuable to New Zealand as the principal supplier to the United States of wools of this type.

Dairy Produce

Returns for butter exports during 1960, at £50·1 million, some £6 million below the 1959 figure, were reasonably satisfactory, but the outlook for 1961 is not good. A favourable season for dairy

production in Europe, including the United Kingdom, substantially increased supplies of butter coming on to the United Kingdom market. As a result, the United Kingdom butter market failed, in 1960, to show the buoyancy usual for that period of the year, and the unusually heavy quantities coming forward in early 1961, especially from United Kingdom domestic production, have further depressed prices. Action has been taken by the New Zealand Government, through direct representations to countries selling to the United Kingdom at subsidized prices, and through special discussions within the GATT, to seek an improvement in market conditions. In addition, the United Kingdom has asked European exporters to take remedial action in accordance with recommendations approved in 1960 by the Organization for European Economic Co-operation.

Sales to markets other than the United Kingdom in 1960 were: butter 15,000 tons (about 10 per cent. of butter exports); cheese 5,000 tons (about 6 per cent.).

Butter is the only major foodstuff in which world trade has not regained the pre-war level. There are two reasons for this: first, margarine has tended to displace butter, particularly where countries which are large net importers of oils and fats have developed domestic production of margarine; secondly, butter production in the main consuming countries has been fostered by high price supports and rigid protection. In some cases output has, therefore, risen to the point where in good seasons there is a surplus of high-cost butter which has to be sold off in export markets with the aid of subsidies.

Exports of casein at 28,000 tons were slightly lower in 1960 than in 1959, while there was a drop of about 10,000 tons in exports of dried and condensed milk, though the value of the lower volume of exports was almost equal to that in 1959. Cheese exports at 79,000 tons were slightly lower than in 1959.

Meat

The general upward trend in world production of carcass meat has continued in recent years, owing to (a) technological improvements, and (b) a strong consumer demand for meat.

In New Zealand, cattle numbers have shown only a moderate increase since about 1954, but there has been a marked expansion in those of sheep. Pasture improvement by aerial topdressing and re-seeding has been an outstanding feature in New Zealand since the war.

Notwithstanding the growth in human population, the rise in world carcass meat production in recent years has been sufficient to permit an increase in *per caput* consumption in many countries.

The number of sheep in New Zealand continues to increase as can be seen from the following figures:

June 30	*Total No. of Sheep (millions)*	*No. of Breeding Ewes (millions)*
1957	42·4	28·9
1958	46·0	30·9
1959	46·9	31·8
1960	47·1	32·6

A record quantity of 467,000 tons of frozen and chilled meat was exported from New Zealand in 1960. This comprised beef £20 million, veal £2·3 million, lamb £44 million, mutton £4·6 million, and pork £700,000, with edible offals accounting for the bulk of the remainder. Total export values at £76 million were some £5 million above the 1959 figure.

The pattern of trade did not change greatly; for every four tons of meat exported, some three tons went to the United Kingdom. A marked increase in the supplies of lamb coming on to the United Kingdom market, both imported and home-produced, led to a decline in the prices of lamb in the second half of 1960, but prices showed a rising trend in the first three months of 1961.

Total exports of meat to the United States declined in 1960 as compared with the previous year, largely because of a fall in sales of beef, but this was offset by a rise in beef exports to the United Kingdom. There were two important developments during 1960 in New Zealand's trade with the United States. In May, the United States Tariff Commission unanimously agreed that imports of fresh chilled and frozen lamb and mutton had not injured domestic industry. By a majority decision the Commission also decided that imports did not threaten injury to the domestic industry and that restrictions on imports should accordingly not be imposed. By the end of 1960 the Meat Export Development Co. (N.Z.) Ltd. had taken over the control of all lamb exports to North America, and early in 1961 the first shipments were made by the company to the United States and Canada.

Lamb, beef, and veal exports to Canada showed an increase of about 25 per cent. over the previous year, while the quantity of meat shipped to Japan—mainly mutton—increased about five-

fold over 1959. These two countries offer perhaps the greatest potential as expanding markets for New Zealand meat. Japan is already second only to the United Kingdom as a market for New Zealand mutton, taking over 16,000 tons in 1960.

The recovery in world trade in mutton and lamb, which began in 1958, continued in 1959, when total exports were the highest recorded since 1947. The latest increase was almost due entirely to heavier shipments from New Zealand. New Zealand exports alone represented 74 per cent. of the world figure in 1959, and rose by 19 per cent. over 1958 (but showed only a slight increase in value terms). The United Kingdom took well over 90 per cent. of New Zealand exports of mutton and lamb.

United Kingdom statistics show that from 1938 to 1959 imports of mutton from New Zealand increased from 50,700 tons to 58,200 tons, compared with a fall in total United Kingdom imports of mutton in that period from 80,200 tons to 69,200 tons. Lamb imports from New Zealand, in the period 1938 to 1959, increased from 133,000 tons to 237,000 tons (almost doubled) while total United Kingdom imports of lamb expanded only slightly (264,200 tons to 289,600 tons). In 1959, therefore, New Zealand supplied 295,200 tons, or 81 per cent. of the United Kingdom total imports of mutton and lamb compared with 53 per cent. of total imports in 1938.

Over 80 per cent. of New Zealand's beef and veal exports were sent to the United Kingdom in 1954 (before the end of the Bulk Purchase Agreement) but subsequently this proportion declined sharply and amounted to only 11 per cent. in 1958 and 8 per cent. in 1959; in 1960 some 21 per cent. went to the United Kingdom.

In 1959, United Kingdom imports from New Zealand were as follows:

Chilled beef: 100 tons in a total of 207,800 tons.

Frozen beef: 5,500 tons in a total of 135,400 tons.

Veal: 1,700 tons in a total of 6,400 tons.

The United States became the main outlet for beef and veal in 1958, and in 1959 took 78 per cent. of a smaller output.

Hides and Skins

Exports of hides and skins, which had increased sharply in 1959, also increased slightly in 1960, although the value remained almost constant at £13·3 million. The largest category, sheep and lamb pelts, is also the one in which most of the increase has been recorded during 1959 and 1960. In the latter year, exports of this

product were valued at £8·6 million, with cattle hides next in value at £2·5 million, followed by woolly sheepskins and calf skins, each about £900,000.

The main market is the United States, which bought about £5 million or 37 per cent. by value of all New Zealand exports of hides and skins in 1960 (and almost 80 per cent. of lamb pelts exported). Other substantial buyers include the six countries of the European Economic Community (EEC), the United Kingdom, and Japan.

Problems in World Trade

Over recent years the prices which New Zealand has received for exports have not kept pace with prices which have had to be paid for imports. This has resulted in the terms of trade moving against New Zealand. In other words, 100 units of exports which would have purchased 100 units of imports in 1957 has been estimated to purchase only 95 units in 1960. Agricultural protectionism exists in many of the main markets, with the result that access to those markets is becoming more difficult. In addition, the problems of surplus disposals and price support schemes must be faced.

In many countries the income level of farmers is low compared with that in other occupations. Most countries therefore encourage farm production through price support schemes. Such schemes often increase uneconomic and inefficient production and result in unreasonably high prices to the consumer. With markets virtually closed to imports, and a drop in the internal demand, surplus production is generated and thus in a number of cases (notably butter) the inevitable result is subsidized exports.

Now New Zealand is faced with the possibility of the United Kingdom becoming associated with the EEC.

All these problems create market insecurities for New Zealand which is affecting the realizations from the main export items. For New Zealand, the export trade in food is of overwhelming importance; so is the European, or rather the United Kingdom, market. Most forecasts of agricultural output in New Zealand see a persistent drift from the land, combined with an annual rise in output of between 2 and 2½ per cent. But while this annual increase is not automatic, and depends upon the continuing use of the most up-to-date farming equipment and techniques, the basic problems facing the New Zealand farming community today lie in the field of overseas marketing. And the role of Government is indispensable in dealing with these problems.

These marketing problems relate more particularly to dairy produce and meat because it is these products, together with cereals, which are the most highly protected by industrial countries.

And there must still be increased production. Producing greater quantities will not be difficult, but selling greater quantities to the world presents another problem, and it is here that the need for a partnership between producers, Government, secondary industry, and commerce really exists.

There are a variety of marketing arrangements for these products, ranging from the free auction system of wool through to monopoly marketing by Statutory Boards. Whatever the system of disposal might be, there is a definite need for the further development of overseas markets, both the traditional markets and the establishment of new ones. The uncertainty of markets can, and will, limit production expansion.

Selling wool, dairy produce, and meat overseas is no longer an uncomplicated job. New Zealand is faced with the retention of existing markets, the accessibility of new markets, and the fact that producers in other countries enlist Government aid to support and protect their own output. Tariff walls are encountered subsidies in various forms, and international agreements; inevitably the role of Government is becoming increasingly important in matters of overseas trade.

New Zealand has participated actively in international forums such as GATT and FAO urging more liberal trade policies in agricultural products. Domestic price policies more in accord with world levels would avoid the necessity for heavy import restrictions on agricultural produce. Her efforts and those of similarly-minded countries have borne some fruit.

From the New Zealand point of view, the most disturbing aspects of the present world agricultural marketing scene are developments in Europe. In essence, the EEC proposals for agriculture would build into the policies of the Community the illiberal philosophy which has been characteristic of the policies of the individual members of recent years.

The EEC proposals focus particular attention on the dairy industry, and to a lesser extent the meat industry. However, no special provisions are contemplated for mutton and lamb beyond a high common external tariff—a type of protection which does at least provide some scope for negotiation of access on reasonable terms.

The United Kingdom is the principal market for most of New Zealand's products; it is also the only free market of any scale for dairy produce and, with the exception of the United States, for meat. At present, and until 1967 at least, New Zealand can export as much primary produce and meat as she wishes to the United Kingdom and she knows that it can be sold at prices determined by market forces. But in Europe and North America prices for dairy produce, grain, and some other commodities (but not meat) are maintained at artificially high levels; there is thus no prospect of consumption expanding to absorb the supplies available. The introduction of such an agricultural pricing system into the United Kingdom would have difficult consequences for New Zealand.

The possibility of the United Kingdom joining the European Economic Community might now be considered. The United Kingdom has, since mid-1960, persistently sought on both economic and political grounds some bases for an accommodation with the EEC. At the same time, the United Kingdom acknowledges that there are substantial obstacles in the way of this. These have been stated as:

(1) The United Kingdom's agricultural support policies, which are basically different from the proposed agricultural policy of the EEC.

(2) Existing Commonwealth trade patterns which are not easily reconcilable with the United Kingdom membership of the EEC involving acceptance of a common external tariff.

(3) The United Kingdom's obligations to its EFTA partners.

(4) The supra-national aspects of the EEC's various institutions which would not be politically acceptable to a large body of opinion in the United Kingdom.

Public statements by United Kingdom ministers have indicated that the acceptance of supra-national institutions is possible, but, although on agriculture a solution is considered feasible by some, there is still a large following amongst the farmers who would not agree. Solutions to the remaining two issues are not nearly so easy.

If the United Kingdom becomes a full member of the EEC, the adoption of the EEC common external tariff and the removal of internal tariffs on products from other member countries, combined with other EEC import restrictions imposed on non-member countries, would mean for the Commonwealth the barrier of a tariff and the discontinuance of unrestricted entry to the United Kingdom market.

This would have most serious consequences for New Zealand. Apart from losing the Commonwealth privileges of duty-free unrestricted access in the United Kingdom market, products from EEC member countries (hitherto treated on a most-favoured-nation basis) would receive preference in the United Kingdom market over Commonwealth products. For instance, the EEC external tariff on beef and veal is to be 20 per cent. Commonwealth supplies enter the United Kingdom duty free at the moment whilst European supplies pay the United Kingdom most-favoured-nation duty of $\frac{3}{4}$d. per lb (chilled) and $\frac{2}{3}$d. per lb (fresh or frozen). If the United Kingdom joins the EEC, supplies from other EEC member countries would come in duty free at the end of the transitional period whilst Commonwealth countries would be liable to the EEC external tariff of 20 per cent. In addition, there is a system of levies involved for beef and veal which would have the effect of restricting supplies from low cost and efficient producers which could surmount the 20 per cent. tariff.

For mutton and lamb, both Commonwealth and other suppliers to the United Kingdom market have duty-free entry at present, so the Commonwealth has no tariff preference. As the EEC external tariff on these products is to be 20 per cent., if the United Kingdom joins the EEC this duty would be imposed on Commonwealth supplies whilst EEC sources would have duty-free access. The existing draft common agricultural policy of the EEC does not cover mutton and lamb and so the question of a levy does not arise. Although there is not the problem of alternative supplies of mutton and lamb from the European countries, New Zealand's exports would have to bear the 20 per cent. tariff, and the relative cost of imported supplies of mutton and lamb, compared with internal tariff-free supplies of all meats, could easily affect the demand position.

New Zealand, apart from losing the benefit of duty-free unrestricted access into the United Kingdom, also has the prospect, therefore, of a preference being erected against her for meat (as well as other products) in favour of supplies from EEC member countries.

For raw wool and hides and skins there is no EEC external tariff and therefore New Zealand's relative position in the United Kingdom market would remain unchanged.

The illustrations on meat show clearly the reason why New Zealand is seriously concerned with the current discussions on whether the United Kingdom is going to join the EEC and accept

the common agricultural policy (which at the moment is in "proposal" form and still needs to be ratified by the EEC member parliaments).

Apart from the impact of the tariffs and import restrictions of the EEC on New Zealand, given a comparatively static position based on existing trade, what is more important is trying to assess the effects in the future when the carefully regulated and planned agricultural policies of the EEC member countries will be bound to increase their internal production and reduce the need for imported supplies—although, of course, it is expected that internal demand should increase.

Only a brief reference to the EEC problem can be given here, but it is hoped that this should give some indication of the situation confronting New Zealand.

The actual decision of joining the EEC must naturally remain with the United Kingdom but wherever possible New Zealand has given its opinion based on the facts that are available. What has to be fully considered is the relative weight to be given to the political need for United Kingdom union with Europe against the economic advantages or disadvantages of changing a particular trade pattern to another one.

The New Zealand Government can do statistical exercises on this or that alternative type of United Kingdom association with the EEC (Agriculture—*in*; Agriculture—*out*, and the various steps in between) but the numerous combinations and permutations of possible factors can make this type of exercise rather fruitless until more details are known.

New Zealand's range and quantity of exports have been developed on a certain relationship with the United Kingdom—that of duty-free and unrestricted access—and as far as this country is concerned the position should continue. This has been made clear to the United Kingdom on many occasions and New Zealand has been assured of consultations if a change in the position is being considered.

The Government is fully alive to the implications of the present fluid situation and every effort is being made to ensure that New Zealand exporters are not going to be confronted with changed conditions in their main export market.

Prospects for 1961

What are the prospects for New Zealand's overseas trade in primary produce in 1961? International markets exist for wool

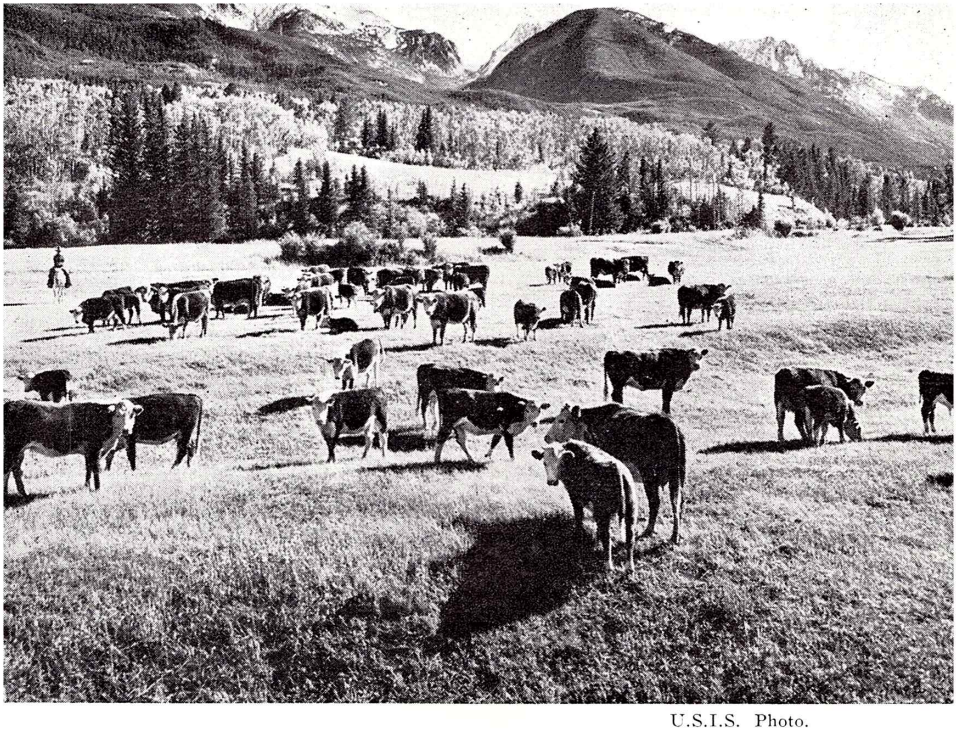
and meat: that for wool is of greater size and variety, and will therefore be influenced primarily by the level of world economic activity; but the market for meat, while sizeable, is threatened by protectionist policies.

For dairy produce, the United Kingdom is the only international market of significance. Some of the surpluses being produced uneconomically by the protectionist dairy policies of most European countries are being dumped there, and the effect on prices is drastic.

Present estimates postulate fairly stable but slightly lower gross returns for wool, meat, cheese, and "other" exports, but a bad year for dairy products with a consequent drop of from 4·5 to 5 per cent. in total export receipts. Unless there are developments which would justify an upward revision of estimated receipts, it appears that New Zealand's total export returns for 1961 will be below that of the preceding two years.

In this situation, the Government's trade policy continues to give emphasis to expanding and diversifying export markets within the limitations imposed by existing conditions governing access to these markets. It is evident also that continuing efforts must be made to modify national agricultural policies which are the root cause of restrictions; future trade prospects are increasingly dependent on the success of these efforts.

In the long view, dependence on wool, meat, and dairy products for export earnings is inescapable. New Zealand's primary industries have always carried the major part of the responsibility for earning export income, and there is little doubt that primary industry is expected to carry on in this role for many years to come. Therefore, the importance of primary products in relation to the balance of payments cannot be too strongly emphasized.



U.S.I.S. Photo.

Hereford cows and calves on the range in Montana.

IMPRESSIONS FROM AN AMERICAN VISIT—BEEF CATTLE, SHEEP AND MEAT

R. A. BARTON*

THE GROWING IMPORTANCE of the United States of America to the prosperity and military security of New Zealand and other Pacific countries needs no reiteration here. New Zealand will be concerned increasingly in the future with this largest world group of English-speaking peoples who enjoy high standards of living and are experiencing rapidly expanding populations. They, too, have the desire to trade, not only to market their surplus agricultural and industrial products but because they are realizing that trade brings friendship between nations.

The purpose in spending seven months in the United States was to carry out lamb carcass investigations at the United States Department of Agriculture's Research Center at Beltsville, Maryland, and to study developments in the meat industry and to survey beef cattle production methods and research. Some observations and impressions of this visit will be considered in this paper.

**Massey Agricultural College, Palmerston North.*

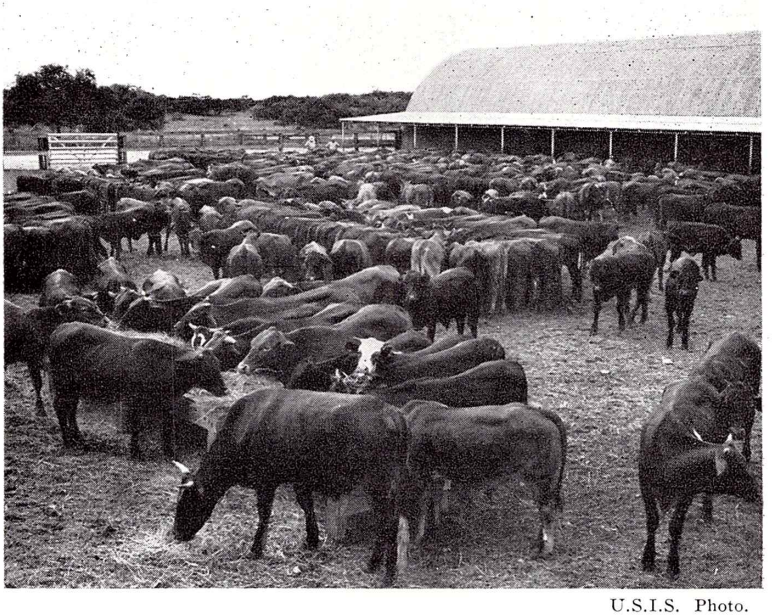
The Beef Cattle Industry

There are approximately 100 million cattle in the United States, excluding Alaska and Hawaii. Of this number, 68 million are beef animals. The national beef herd includes 27 million breeding cows and heifers two years and old, 7·4 million heifers under two years of age, 11 million steers over one year of age, 21 million calves, and 1·7 million bulls older than one year of age.

Dairy cow numbers have been declining; they have dropped by 23·2 per cent. from their peak figure recorded in 1945, while beef cow numbers have increased to 25·6 million, or by 55·6 per cent., in the same period (1945-1959). Beef cows are likely to continue to increase in numbers to match the growing human population which is increasing at about 3·2 to 3·4 million per annum and now totals about 182 million. Predictions are that by 1970 the human population will reach 214 million, by which time the cattle population will be 123 million head.

This estimated level of cattle production will result in a supply of beef and veal by 1970 equal to 105 lb carcass weight per person. This figure is 10 lb above the highest-ever supply of beef and veal which was recorded in 1956. Consumers, however, have enjoyed increased spending power in recent years and there is no reason to believe that this trend will not continue; hence it is altogether likely that the extra beef production will be absorbed at reasonable prices. This is all the more likely because of the increasing proportion of teenagers in the population who are heavy eaters, especially of sausage-like foods such as weiners, hot dogs and hamburgers, derived mainly from beef.

There have been important advances in cattle husbandry which have also had effects on quality and supply. Cattle are now younger at slaughter but their average dressed carcass weight has risen steadily over the past thirty years and is now 550 lb. Forty years ago the average age of steers on ranches and farms was 32 months on January 1, but today their average age is about 20 months as at that date. Furthermore, the figure of calves born as a percentage of cows and heifers two years old and older at January 1 has increased from 74—recorded in 1924—to 86 in 1960. There has also been a reduction of about 20 per cent. since 1945 in the death losses of cattle and calves. Along with these changes there has been an increase in the proportion of beef cattle to total cattle and more and more of these cattle are being finished off in feed-lots prior to slaughter.



U.S.I.S. Photo.

Young steers, predominantly of the Santa Gertrudis breed, in a feed yard on the King Ranch in Southern Texas.

Breeds of Beef Cattle

Hereford cattle in America are by far the most common of all breeds, followed by the Aberdeen Angus and the Shorthorn. Polled strains of the Hereford and Shorthorn breeds are increasing sharply in numbers but so also is the Brahman and its derivatives such as the Santa Gertrudis. Brahman-type cattle are gaining in popularity in the southern region of the country as they are better adapted than British breeds to the feed conditions, high temperatures and humidity of the region.

Apart from the Santa Gertrudis breed, which was evolved at the King Ranch in Southern Texas by crossing Brahmans and Shorthorns and stabilizing the cross at three-eighths Brahman and five-eighths Shorthorn blood, there have been other crosses made and breeds developed from them. For example, Brangus cattle are based on three-eighths Brahman and five-eighths Aberdeen Angus blood. The Lasater Beefmaster was developed from foundations of Brahman, Shorthorn and Hereford cattle, and the term

"Lasater Beefmaster" is a trademark and has been copyrighted through the United States Patent Office as there is no breed association.

The massive French breed of cattle called Charollais has been imported to America by way of Mexico in recent years and, by crossing it with the Brahman, a breed called Charbray is being developed for the Gulf Coast region.

Crosses among the three British beef breeds are not common and, in fact, the respective Breed Associations attempt, through propaganda, to discourage this breeding practice.

Breeding Superior Beef Cattle

Within the last 15 years there has been much interest aroused in attempting to breed cattle of enhanced growth rate. Testing of the liveweight gaining ability of young bulls, either on the home ranch or at a central station, has become an important feature of stud cattle production. Cattle on test are weighed at regular intervals while kept under standard environmental conditions, and the results are expressed as pounds of gain per day.

Experimental work has shown that, about 80 per cent. of the time, bulls which grow the fastest in the feed-lot will sire the fastest growing calves. About 20 per cent. of the time, the reverse will be true. The progeny test, however, will give a more complete appraisal of the breeding worth of a bull but there is a delay in obtaining the results of the test. Therefore it is probably desirable to select the bull on his own weight gain even though occasionally a selected fast-gaining bull may leave slow-gaining offspring.

The American Angus Association has recently developed a herd improvement record which takes into account liveweight gains of calves and yearlings as well as type classifications. The whole programme is voluntary but is under the control of the Association.

The huge meat-packing organization of Armour and Company has also moved into the task of producing cattle of superior merit. This company has created a set-up known as B C I (Beef Cattle Improvement Research) with headquarters in Denver, Colorado. B C I has set ten achievement goals in its programme and these aim to produce:

(1) Animals of 900 to 1,100 lb liveweight, yielding dressed carcasses of 550 to 700 lb.

(2) Carcasses with firm, white fat cover uniformly distributed—no thicker at the 12th rib than one-tenth inch per 100 lb dressed weight.

U.S.I.S. Photo.

Registered Brahman cattle of Indian origin in Southern Florida. This breed is well adapted to conditions of high humidity and temperature. It is crossed with British breeds in the Gulf Coast region.

(3) Carcasses with at least 48 per cent. of their weight in the hindquarter when cut between the 12th and 13th ribs.

(4) A ribeye muscle which is bright red, firm, finely textured and has, at the 12th rib, at least two square inches of lean area per 100 lb of dressed carcass weight.

(5) The yield of primal cuts per side to be no less than $22\frac{1}{2}$ per cent. for round, $17\frac{3}{4}$ per cent. for loin and $9\frac{1}{4}$ per cent. for rib.

(6) The rate of gain of steers is to average not less than 2·25 lb per day from birth till slaughter or 1·4 lb on dressed carcass basis.

(7) The marbling of the ribeye is to be abundant and finely dispersed.

(8) Tenderness of the cooked meat is to be no less than 6 (medium tender) as determined by a taste panel on a scoring system where 1 is extremely tough and 8 extremely tender.

(9) Kidney and suet fats are not to exceed 3 lb per 100 lb of carcass weight.

(10) The bone is to be a deep red colour, indicating youth.

Cows on co-operating ranches are inseminated free of charge with semen from progeny-tested sires and, in return, ranchers must keep herd records and sell to B C I their steer calves and any heifer calves not needed for herd replacements. In this way, Armours obtain fattening cattle of superior breeding in terms of growth rate and carcass quality for eventual slaughter in their

meat-packing houses. The whole project is an ambitious one and is a demonstration of the large-scale use of scientific knowledge to produce better beef economically.

Dwarfism Among Beef Herds

The stud beef cattle herds are recovering from the shock of dwarfism which they experienced at its worst mainly in the late 1940's and early 1950's. The birth of dwarf calves in Hereford, Aberdeen Angus and Shorthorn stud herds, and later in commercial herds, caused widespread consternation. The dwarfs had no economic value and many died at birth or shortly afterwards. They were produced mainly by fashionably bred sires and dams. Dwarfs have short, dished faces, lower jaws which protrude beyond the upper dental pad, prominent foreheads, pot bellies, and they suffer from nervous inco-ordination and difficulty in breathing.

The incidence of dwarfism has been greatly reduced as the result of eliminating known carriers of the hereditary condition. This has been achieved largely by pedigree analysis but detection of the carrier animals by means of various tests, including the use of the profilometer to reveal differences in head shape, X-rays of the vertebrae of the loin of young calves, counts of certain types of blood cells following administration of insulin, and a study of the cerebrospinal fluid. None of these tests is more than about 70 per cent. efficient in detecting carriers of the genetic condition. The issue of a so-called "clean" pedigree by the Breed Association is not a guarantee that the animal is free from dwarf ancestry because pedigree inaccuracies are known to occur quite frequently.

Dwarf calves have been born in New Zealand in the three main British beef cattle breeds and it is to be hoped that breeders are doing everything possible to eliminate this hereditary condition before it becomes widespread in stud and commercial herds of this country.

Types of Beef Cattle

Many of the leading stud cattle herds in America are owned by men who have made their wealth in industry and have become cattle breeding hobbyists. They spend enormous sums of money on land, plant and stud stock, and it is they who largely create the fashionable cattle. Such cattle, however, although magnificent to look at, are quite unrealistic from the point of view of producing offspring suitable for the main cattle-raising regions of America or, for that matter, elsewhere.

Cattle of the "improved" type have been called Comprests in the case of Herefords, and Compacts in Shorthorns, and these types

have been compared experimentally with conventional cattle. They were shown to have very distinct disadvantages in terms of reproductive rates, weaning weights of their calves, dressing-out percentages, and their carcasses were not superior to those of conventional cattle. Most of the dwarf calves born in herds were the progeny of the Comprest and Compact types and, because of this and their other disadvantages, they have lost popularity. There is a trend now toward more size and ranginess but without loss of thickness of body. This development, however, may not go far enough to be of real value to the range cattlemen who are producing animals under extreme conditions of sparseness of feed, scarcity of water and wide fluctuations in temperature between seasons.

Research in Heifer and Cow Nutrition

Important cattle-feeding studies of interest to New Zealand breeders are being carried out at three locations, namely, Oklahoma State University, U.S. Department of Agriculture, Beltsville, and at the Iberia Livestock Experiment Station at Jeanerette, Louisiana. The Oklahoma studies* are concerned with the level of feeding of heifers and winter feeding of breeding cows.

Detailed information on the Oklahoma experiment is given in Table 1. The beef females on the low level of winter feeding received 1·0 lb cottonseed meal per head daily, those in the medium group received 2·5 lb cottonseed meal per head daily, while the females in the high group were fed 2·5 lb cottonseed meal plus 3·0 lb oats per head daily. The cattle were continuously on native grass pasture and they received the supplementary feed from early November to mid-April each year. Half of the heifers in each of the three groups were bred to calve first as two-year-olds and the others to calve as three-year-olds.

Apart from oats, the winter feed supplement given to the females in this experiment is not available to the New Zealand beef breeder. The important lesson to be learnt from the experiment, however, is the influence of varying degrees of weight gain or loss in each winter on the breeding cow's efficiency. These gains or losses in liveweight can be achieved in the winter under pasture, hay, silage

*A colour film entitled *Level of Wintering as it Affects the Production of Beef Cows* was shown during the Meeting subsequent to the presentation of this paper, and this depicted in word and scene the findings of the Oklahoma group of research workers. The whole-hearted co-operation of Dr L. S. Pope of Oklahoma State University in making this film available is gratefully acknowledged.

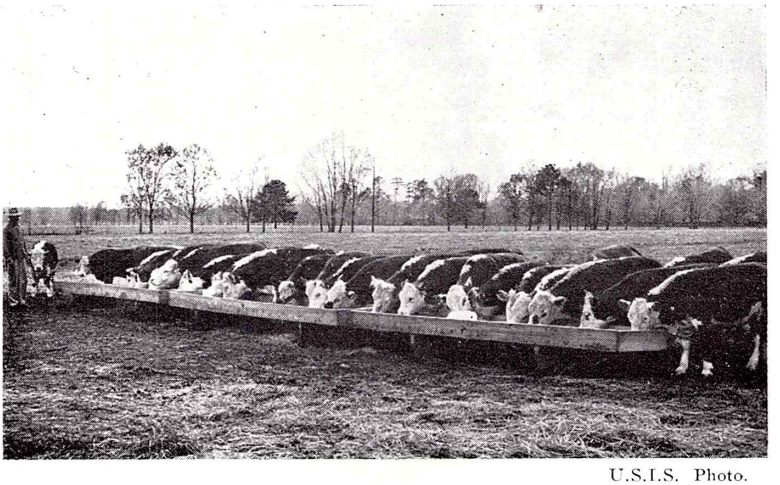
or crop feeding conditions and would presumably have comparable effects on the performance of beef breeding females although this needs to be verified under New Zealand conditions.

TABLE 1: Long-time effects of different amounts of supplemental winter feed on the performance of spring calving beef cows. (Data by courtesy of Dr L. S. Pope, Oklahoma State University, U.S.A.)

	Level of Supplemental Winter Feed		
	Low	*Moderate*	*High*
No. cows starting test, Oct., 1948	30	30	30
No. cows remaining, July, 1960	27	18	14
Av. weight change each winter in lb:			
First winter as calves (gain)	22	59	88
Second to fifth winters (loss)	— 153	— 119	— 92
Sixth to eleventh winters (loss)	— 130	— 131	— 109
Liveweight in lb, Oct., 1959	1,092	1,147	1,120
Total no. calves weaned	252	219	205
Per cent. calf crop weaned	94·6	86·7	87·3
Av. calving date:			
First calf crop	14 Mar.	7 Mar.	8 Mar.
Second to fifth crops	12 Mar.	5 Mar.	3 Mar.
Sixth to ninth or tenth crops	15 Mar.	14 Mar.	12 Mar.
Av. calf weight in lb:			
At birth (corrected for sex)	77·8	77·2	78·6
At weaning (corrected for age and sex)	488	477	479
Cow cost per 100 lb of calf weaned:			
Dollars	7·22	10·59	13·92
New Zealand currency	£2 11s. 2d.	£3 15s. 0d.	£4 18s. 10d.

The results have also indicated that heifers poorly fed in the winter may eventually attain the body weights and size of their moderately and well-fed mates. At maturity, the effect of poor winter feeding on the cows is negligible provided spring and summer feed is plentiful. The cows poorly fed in the winter, when allowed to gain weight in the spring and summer, wean a higher proportion of calves and these have heavier weaning weights than the calves out of moderately and heavily-fed cows. Feed costs, as would be expected, favour the poorly-fed cows.

The same cows have been continuously under test for 12 consecutive years and, of the 30 cows which started in each test group, there remain 27 in the low group, 18 in the moderate group, and only 14 in the high level of winter feeding group. One of the main reasons for the greater loss of cows in the group fed at a high level



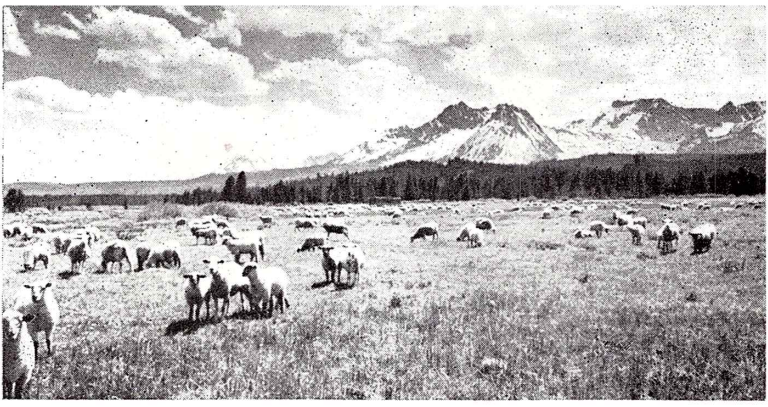
U.S.I.S. Photo.

Hereford steers being fed a ration of maize cob shuck and soybean meal to bring them to market finish.

has been failure of cows to conceive or raise a calf for two consecutive years and, accordingly, some have been culled. Identical twin beef heifers have also been used in feeding experiments. It was found that the milk production of the twins fed very well prior to calving has been substantially less during their first lactation than the level of milk production achieved by their moderately-fed co-twins.

The Beltsville and Louisiana studies are concerned with continuous feeding of rations of various energy and protein contents. Preliminary findings indicate that heifers fed on a medium energy-medium protein ration have the best reproductive performance. Low feed intakes have been shown to delay attainment of puberty, have failed to maintain regular heat cycles, have increased the interval from calving to subsequent first heat and have reduced milk production. Heifers fed on high energy levels were extremely fat at first calving, and death losses in their calves were high.

In summary, the Oklahoma experiments demonstrate the great capacity of beef cattle to recover lost weight and the wisdom of not feeding breeding cows liberally in the winter. The Beltsville and Louisiana studies, on the other hand, show that continuous undernutrition will result in very poor performance of beef cows in terms of reproduction, milk production and growth.



U.S.I.S. Photo.

Fine-wooled ewes with black-faced lambs on upland pastures in Idaho.

The Sheep Industry

At January 1, 1960, the total sheep population of the United States of America was 33·6 million. This total was made up of 22·7 million ewes, one year old and older, 4·8 million ewe lambs, 0·8 million wethers and, in addition, there were 4·1 million sheep and lambs (mainly lambs) on feed. It is of some interest to note that the national lamb crop is now about 20 million which is equal to 96 per cent. of the ewes one year of age or older at January 1. This lamb crop percentage has risen steadily from the figure of 85 per cent. recorded in 1948.

During the past decade, the number of breeding sheep on ranches and farms at the beginning of the year has averaged about 25 per cent. smaller than it did 80 years earlier. There was a precipitous decline in sheep numbers during the war and post-war period of 1942-50, when breeding sheep numbers were reduced by almost 50 per cent. Sheep numbers have increased moderately since 1950 but the increase was interrupted during 1955-57 by a severe drought in a number of western States. Last year there was an increase of about one million head to bring the total to 33·6 million sheep.

The sheep industry of America, in spite of recent numerical increases, is in serious difficulties. Its problems have come about mainly as the result of high costs of labour, plant, and feed, low net returns for lamb and wool, non-renewal of grazing rights by the Federal Government, and failure to control internal parasites, marauding dogs, predatory wild animals, poisonous plants and eliminate sheep scab—an external parasite which was eradicated from New Zealand flocks in the 1880's. The traditional attitude towards sheep is to regard them as scavengers and capable only

of cleaning up weeds along ditches, around buildings and on crop land. The cattlemen also regard them with disdain and as spoilers of cattle pastures.

Another major difficulty of the sheep industry is the small size of most of the flocks. Sixty to one hundred or so sheep is a very common size of flock in all parts of the United States except on the range country of the West. This means that sheep, in the main, are a side-line venture and as such are not given much thought and attention. Culling, ram selection, weaning, flushing, mating, lambing, docking, shearing and wool preparation in the shearing shed, control of internal and external parasites and of diseases like foot rot and those controllable by vaccination, can seldom be carried out efficiently in flocks of very small size because they do not warrant the installation of the best and most suitable equipment nor do they justify the employment of skilled labour.

Types of Sheep Production

There are three main types of sheep producers:

(1) Those who maintain farm flocks of a few to several hundred head.

(2) Those who graze large bands (or mobs) of sheep on the open range.

(3) Those who purchase and feed lambs for eventual slaughter.

Nearly half of the total lambs produced in America come from 4,000 ranches or farms having flocks of a thousand or more sheep each. These are located mainly in the 13 range States (South Dakota, Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, Utah, Nevada, Washington, Oregon, California and Texas). The remainder of the lambs produced come about equally from farms or ranches having between 100 and 1,000 sheep each, located predominantly in the range States, and from farms having less than 100 sheep on which sheep raising is incidental to other farming pursuits. Some 250,000 farms having less than 100 sheep are located largely in the central and eastern States—the so-called native sheep States (Pennsylvania, Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, Nebraska, Kansas, Virginia, West Virginia).

The range States, in which only a fourth of the sheep farms of the United States are located, produce nearly two-thirds of the total lambs. Texas, Wyoming, California, Colorado, Montana, Idaho and Utah, in that order, are the leading sheep-producing

States. These seven States produce nearly half of the U.S. output of lamb. Iowa, Ohio, Minnesota and Missouri are leading producers among the native sheep States.

About half of the lambs that are slaughtered are slaughtered at weaning time or thereabouts and the remainder are finished in feed-lots where they are fed for an average of 9 to 13 weeks. The length of time they spend in feed-lots depends upon such things as the source of the lambs and their condition, the area where the lambs are fed and the types of feed used and market prices. The preferred type of feeder lamb weighs about 70 to 80 lb; some 30 lb are added to its liveweight during feeding and the average liveweight of the fed lambs when sold is about 105 lb.

Feeder lambs are usually bought during the months of greatest supply and then sold for slaughter when lambs would otherwise be in relatively short numbers. Thus, the feeding operations lend a substantial element of stability to the market and facilitate ultimate delivery of lamb to the consumer all the year round.

There are two types of lamb feeders—farm feeders and commercial feeders. Farm feeders engage in lamb feeding in conjunction with other farm pursuits and their operations are likely to be limited to a few hundred sheep. Commercial feeders, on the other hand, generally operate on a much larger scale and conduct their feeding operations independently of other farming activities. Large feed-lots are to be found in several areas but most notably in the sugar-beet regions of Colorado and in the Corn Belt of the Middle West. Some feeders in the Corn Belt are able to feed as many as three successive flocks in one year. Probably about 5,000 establishments engage in lamb feeding annually, and probably less than 10 per cent. operate on a large commercial scale.

The most important lamb-feeding area is the intermountain region centred on northern Colorado, where beet pulp is available for forage. Other important lamb-feeding States are Nebraska, Iowa, Kansas, California, Minnesota and South Dakota.

It is estimated that about five-sixths of the feeder lambs originate in the 13 western range States and more than a tenth of them in the west north central States; the remainder, perhaps a twentieth of the total, come from scattered areas. About half of the feeder lambs are delivered to the lots during August, September and October. The bulk of the fed lambs, therefore, are sold for slaughter during the months of autumn and winter. Thereafter, a small proportion of the old-crop fed lambs come into competition with new-crop spring lambs.

Lamb and Mutton Production

Although lambs are slaughtered in every State, nearly two-fifths of the total are slaughtered in four States in the following order of importance: California, Iowa, Nebraska, and New York. There are approximately 500 plants which slaughter lambs, usually along with other slaughtering operations, but only about 90 of them slaughter more than 20,000 a year.

Dressed carcass weights of sheep and lambs have averaged about 46 lb in recent years; the average has climbed steadily from the 38 lb recorded in 1921. The statistics do not separate mutton from lamb. It is estimated, however, that the output of lamb accounts for about 92 per cent. and that of mutton for about 8 per cent. of the combined production of lamb and mutton. The slaughter of mature sheep is estimated at about 1·2 million head annually and lambs at about 14 to 16 million. Of the sheep retained for breeding, approximately two-thirds die on the farms and ranches and the remainder are slaughtered. An old ewe is worth only about a quarter of the value of a lamb and, in many cases, may not repay the costs involved in getting it to slaughter. Most of the small output of mutton is boned by the packers that slaughter the sheep and is used almost exclusively as a manufacturing meat. Boneless mutton supplies only a minute share of the total manufacturing meats used in America.

American Wool Production

Total wool production in the United States is below what is considered a safe level for defence purposes and accordingly it is Federal policy to increase production of wool up to at least 350,000,000 lb from its present level of 280 to 300 million pounds. In 1954, Congress passed the National Wool Act to provide for a wool price support programme. At present, wool producers receive a guaranteed average gross payment of 62 cents (53 pence N.Z. currency) a pound for greasy wool. Wool buyers give growers about 42 cents (36 pence) a pound and the remaining 20 cents (17 pence) is paid by the Federal Government out of the tariff collected on certain types of imported wool.

About 31 million sheep and lambs were shorn in 1960 and these produced fleeces which averaged about 8·3 lb. Just over 85 per cent. of all the wool produced is grown west of the Mississippi River and is produced mainly by range flocks in 11 western States of which Texas is the largest wool producer. Nearly half the wool grown is classed as fine, derived from Merino or Rambouillet type sheep, 16 per cent. is halfblood, derived from crosses of fine wool

and long wool sheep, 18 per cent. is three-eighths blood, and 13 per cent. is quarter blood (*i.e.*, quarter fine wool and three-quarter coarse or long wool blood). The remainder of the national clip is classed as off-wools.

Competition for this wool is limited to American buyers who offer a price usually as a sealed bid. The wool is often very poorly prepared for sale and there is no attempt to skirt and class it in the shearing sheds. Each fleece is tied with paper twine and placed in long bags which are pressed only by trampling. Shearing is primitive and most shearers tie the legs of the sheep once the belly wool has been removed. Shearing rates of pay are about twice those ruling in New Zealand. The fleece is usually heavy with yolk, dirt and vegetable matter and its colour is often yellow to brown.

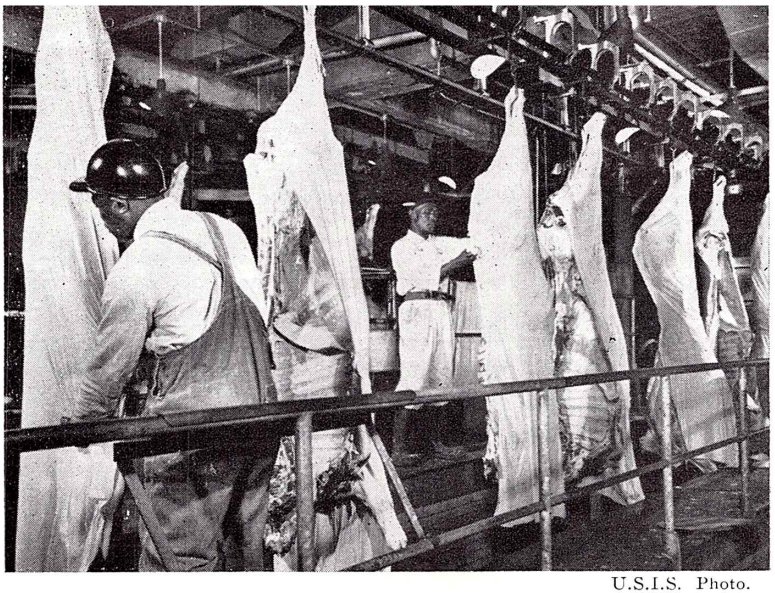
Wool is very definitely secondary to lamb production and, as a result, the producer receives about 25 per cent. of his gross income from wool and 75 per cent. from lamb.

It is not easy to determine what American farmers receive for their livestock because of seasonal fluctuations in prices and different regions have different scales of values. The figures to be quoted, however, are averages of recent realizations. Farmers have been receiving, per 100 lb liveweight, about $19 (£NZ6 14s. 10d.) for lambs, $6 (£NZ2 2s. 7d.) for sheep, $25·5 (£NZ9 0s. 10d.) for calves, and $23 (£NZ8 3s. 2d.) for beef cattle.

Returns on the production of a ewe have been recently calculated by the American Sheep Producers' Council, as follows:

Income from her lamb (83·5 lb liveweight at $18·70 per 100 lb)	$15·61	(£NZ5 10s. 10d.)
Income from her fleece (8·33 lb at 62 cents per lb)	$5·16	(£NZ1 16s. 7d.)
Total	$20·77	(£NZ7 7s. 5d.)
Minus costs for feed, labour, interest on capital invested in land, stock, equipment, etc., estimated to be $100·00 (£NZ35 9s. 0d.) per ewe	$19·00	(£NZ6 14s. 10d.)
Net income per ewe	$1·77	(£NZ0 12s. 7d.)

The low return of only 12s. 7d. per ewe highlights the economic plight of the American sheep producer.



U.S.I.S. Photo.

Light-weight sides of beef at a meat-packing plant being wrapped in muslin prior to moving into the cooler where they will be aged or ripened for up to 14 days before sale and consumption.

Meat

The average American does not eat the quantity of red meat that is eaten by the average New Zealander. The American total consumption is 160 lb whereas the figure for New Zealand is 222 lb per head of the population per annum. New Zealanders each year consume 12 lb more beef and veal, 84 lb more lamb and mutton, but 34 lb less pigmeat than the average American. In addition to this red meat consumption, the average American eats 28 lb of chicken and 6 lb of turkey meat each year. Turkey consumption is thus about 2 lb higher than the average consumption of lamb.

The distribution of lamb and mutton throughout the United States is more uneven than most agricultural commodities. Domestically produced lamb and mutton is consumed primarily in the Middle Atlantic and Pacific regions of the nation. These two regions take 59 per cent. of the total supply. Of the total domestic supply to the Pacific region, California, with its rapidly expanding human population of about 17 million, takes 91 per cent.

On a per head of population basis, lamb and mutton availability for consumption also varies widely among States. Consumption per head is highest in Massachusetts and California, with 12·4 lb and 12·3 lb respectively. Other States with relatively high *per capita* consumption are New York with 11·5 lb, Utah 9·3 lb, New Jersey 8·3 lb, and Rhode Island and Connecticut each with 6·5 lb. Only five other States—Nevada, New Mexico, Illinois,

Arizona and Michigan and the District of Columbia—have higher *per capita* consumption of lamb and mutton than the United States average of just over 4 lb.

Many potential retail store outlets do not handle lamb; in fact, only 39 per cent. of the retail stores in America handling fresh red meats sell lamb. In the north-east, 73 per cent. of the stores selling fresh red meat sell lamb; in the west 54 per cent.; in the north central region 33 per cent.; and in the south only 17 per cent. of the stores sell lamb. Almost 90 per cent. of the stores that sell lamb sell it all the year round and the highest availability of lamb occurs during October, November and December, and it is least available in the stores during June, July and August.

Half the stores selling lamb receive deliveries in the form of whole carcasses, 38 per cent. of the stores in the form of hind saddles (rear half of the carcass), 23 per cent. of them in the form of fore saddles and 10 per cent. receive their lamb supplies as sides. Forty-one per cent. of the stores receive deliveries of other cuts, including mainly legs, shoulders and loins.

These statistics indicate several things of interest to the New Zealand meat producer and exporter. First, lamb in America is far from being regarded as a preferred meat. Secondly, lamb consumption is greatest on the east and west coasts of America. Thirdly, only some of the stores sell lamb and these tend to be those with the largest turnover. Fourthly, there is a substantial demand from stores for cuts and portions of lamb rather than whole carcasses.

A sizable proportion of the total lamb output is consumed by the Jewish population. Orthodox Jews are permitted only to eat meat which has been kosher killed, and it is estimated that the bulk of the lamb slaughtered in the New York metropolitan area is for this kosher trade. The quantity of lamb killed for the kosher trade for the whole of the country is estimated at 25 per cent. of the total production, though not all of such lamb is actually consumed by Jews. Under Mosaic law, Jews are not permitted to eat the flesh of the ribs and hindquarters, and these parts are therefore sold for consumption by gentiles. Kosher meat must be sold within three days of slaughter although it may be held for as long as twelve days with proper ceremonial washings.

New Zealand's Prospects for Selling More Meat in America

New Zealand's prospects for increased disposal of lamb in the United States are good, provided sales are fair and orderly and do not antagonize the domestic lamb producers. This country must

work in the closest harmony with the American producer and do everything possible to assist him to produce and sell more of his own lambs at more profitable prices than he is currently receiving. In this way, markets will expand and goodwill in the fraternity of sheep producers will be created for the mutual benefit of both countries.

There is increasing acceptance of frozen rather than fresh lamb by retailers and consumers who are learning how to handle the product. The institutional, catering and restaurant trades quickly accustomed themselves to the frozen product, especially when frozen imported lamb could be purchased for 10 to 20 cents per lb cheaper than fresh, domestically-produced lamb.

It is possible that the American market may prefer lambs of heavier carcass weight than those New Zealand has been producing. A carcass weighing about 40 lb may be what is needed, but in no circumstances must it contain excess fat. In the opinion of the writer, the lamb trade of the future will be based very largely on cuts rather than on the export of intact carcasses. Exporters will then be able to ship cuts, such as legs, all of approximately the same weight in any one container. This will enable retailers to order from wholesalers a given number of legs, for example, all of a specified weight. Such weight-constant cuts will help caterers and chefs to achieve much better portion control when serving each consumer than hitherto has been possible.

Boneless beef, veal and mutton from New Zealand is meeting market requirements now that the out-turn of the product has been greatly improved. This meat, trimmed of most of its fat is used in the sausage trade and for hamburger ground meat. Consumption of this type of meat is increasing and there is no reason to expect that the trade will not be permanent. Boneless meat must not contain more than 10 per cent. "visual" fat so that very fat ewes and cows are unsuitable for this trade as it is quite uneconomical to trim their excess fat to the specification laid down for the product.

Market realizations for New Zealand meat in the United States will fluctuate according to supply and demand. When America domestic production is high due to drought, low prices, or large production resulting from favourable feed conditions, then the market will not be very attractive to New Zealand meat exporters. In these circumstances America herself may export meat to the world's markets. Down the years, America has exported more meat than she has imported. In the last couple of years, however, im-

ports have exceeded exports but only by negligible proportions in relation to America's total requirements.

Contacts with America must be intensified at all levels—producer, scientific, educational, cultural and political—in order to strengthen ties of friendship and trade. It is a vast continent and travel is costly and tiring, but opportunities for mutual helpfulness are plentiful. Its people are kind and generous and have the drive and vigour that characterize a young country. In the years ahead New Zealand and America will be increasingly linked together in trade to their common benefit of economic and military security and this will be a good thing.

DISCUSSION

Q:: *Is the small quantity of lamb meat eaten by Americans due to limited supply or to a dislike of this meat?*

A:: Most Americans have no desire to eat lamb because they have been brought up on beef, veal, pork and poultry. Attitudes to lamb, as a meat, would need to be changed before its consumption will rise much above the present figure of just over 4 lb eaten per head of the population per annum. The supply of lamb has, of course, been low and its distribution and availability throughout the United States are very uneven regionally and seasonally. The American Lamb Council is doing a good job within the confines of its budget to promote lamb consumption, but a tremendous task lies ahead of it.

Q:: *Is the quality of American sheep meat satisfactory?*

A:: In general, the quality of lamb and mutton appeared to be reasonable. It was usually tender, due very largely to conditioning before sale, and it did not have as much wasteful fat as is present on a good proportion of New Zealand sheep meat. The conformation of the American lamb carcasses was not as good as the general run of New Zealand lambs.

Q:: *Has Mr Barton any comment to make on the fattening of cattle in feedlots?*

A:: Nowadays most steers and heifers in America are finished off in feedlots before slaughter. This feeding of corn and grain, often with hormones, tranquillizers and antibiotics added, produces beef of higher grade and hence higher price. Costs of feed, labour and plant are very high, but losses of cattle are usually low—about one per cent. The practice would be quite uneconomic under present costs and returns operating in New Zealand.

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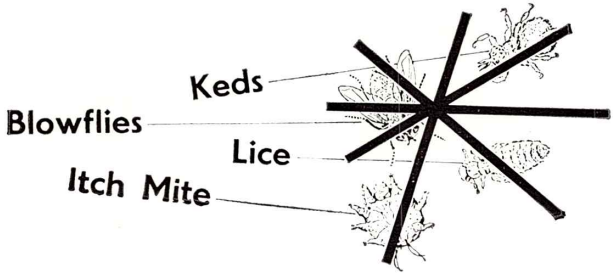

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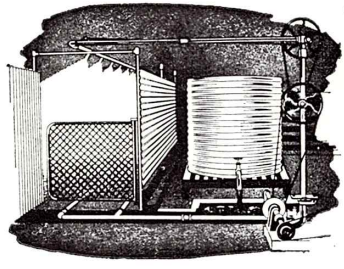

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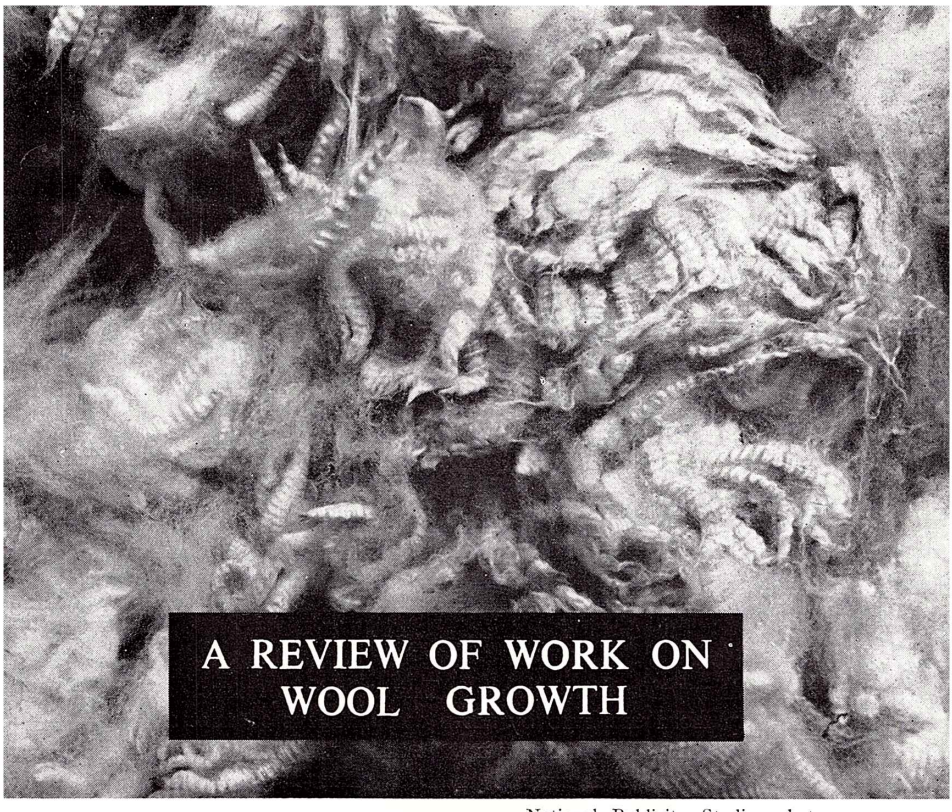

A REVIEW OF WORK ON WOOL GROWTH

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F. COCKREM and A. L. RAE*

THE PURPOSE OF THIS PAPER is to give an outline of present knowledge of the factors underlying the type and amount of wool grown by a sheep. It is the intention to give a review of knowledge rather than an account of individual research projects. At the same time, the relevance of this knowledge to problems in the sheep industry will be discussed.

Although much of the work on the mechanisms of wool growth and fleece type has been done in Australia on Merino sheep, significant contributions have been made from work done at Massey College and elsewhere on the N-type and the ordinary Romney. Sufficient research has been carried out to show that much of the basic information is applicable over a wide range of breeds.

The basic unit of wool production is the wool follicle (Fig. 1). The follicle is an invagination or depression in the outer skin with a very active bulb at its base. It is a part of the skin, and all other tissues, such as fat, lie underneath the follicle. In the bulb, a very

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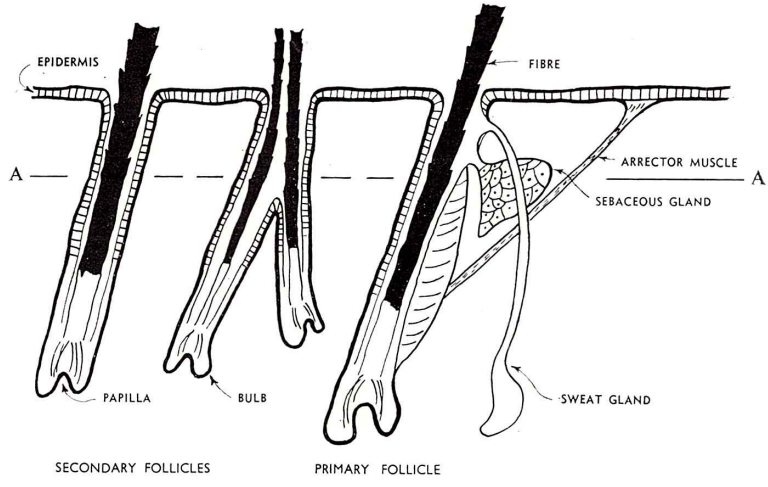

Fig. 1: Wool follicles.

rapid division of cells takes place. The cells thus formed are then pushed up from the bulb by more cell divisions so that a stream of cells is continuously passing up the follicle. As they pass up they become elongated and certain chemical changes take place inside them. As a result of these chemical changes, the cells harden and become keratinized and cemented together. When this process is complete, the cells are dead and are pushed out of the follicle as the wool fibre. This hardening process, or keratinization, is essentially a process whereby long chains of molecules are bound together by means of sulphur atoms. Sulphur is therefore an essential constituent of the wool fibre.

In the formation of the wool fibre there are, therefore, two essential processes: (a) Cell division, and (b) Keratinization of the cells produced. Both these processes require raw materials, for the production of new cells and for the formation of keratin. Energy is required for the building up of these raw materials into the completed wool fibre.

The diameter and length of a fibre produced by a follicle will depend on the size of the bulb and the papilla, and also on the raw materials and energy available to the follicle. The size of the fibre also depends in part on the type of follicle, of which there are two main classifications. In Fig. 1 it will be noted that one follicle has a sweat gland and a sebaceous or wax gland associated with it. This is called a primary follicle and it is the primary follicles which first appear in the skin of the unborn lamb. The

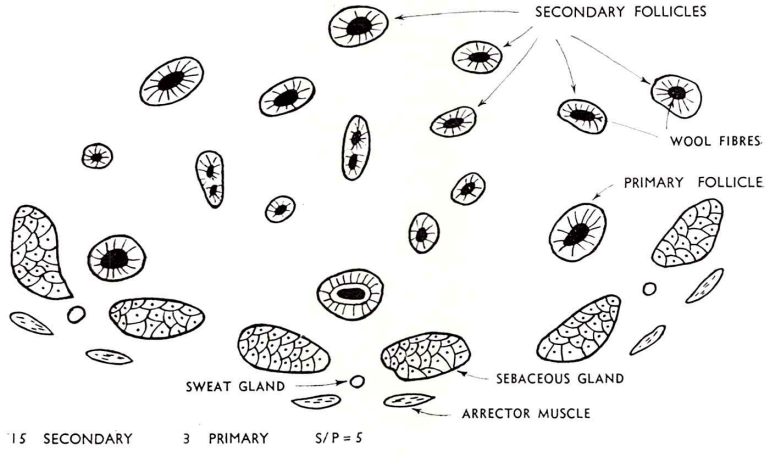

Fig. 2: The follicle group.

follicles which lack sweat glands and, usually, sebaceous glands, are called secondary follicles and appear in the skin of the foetal lamb at a later stage. Nearly all the follicles are, however, formed by the time the lamb is born, although some of the secondaries do not start to grow a fibre until after the lamb has been born.

If a thin section of skin is taken along the line A-A shown in Fig. 1 (as in a plan of a building), and looked at under the microscope, the picture is like that shown in Fig. 2. The section cuts across the accessory glands so that primary and secondary follicles can be identified. It is found that the follicles occur in groups (one group is shown in Fig. 2) with three primary follicles associated with varying numbers of secondary follicles. These groups occur in a fairly regular pattern over the skin.

The number of primary follicles in the skin of sheep does not vary much but the number of secondaries can vary greatly. Therefore, the average number of secondary follicles per primary follicle is a useful measure of the number of follicles in the skin. It has the advantage of being easily estimated in sections from a piece of skin from a sheep. This ratio of secondary to primary follicles is usually called the S/P ratio. The higher this ratio, the higher is the follicle density and hence the density of the fleece. Thus, a primitive carpet-wool type of sheep may have an S/P ratio of 3, a Romney one of about 6, while a fine-wool Merino may have an S/P ratio of 25 or more.

If the amount of raw materials and energy available to a follicle group is constant, then a follicle group with, say, 30 secondaries will have less materials available per follicle than with a group with, say, only 6 follicles. Hence, an animal with many follicles is likely to produce a fleece with more fibres, but each of these fibres will be smaller. Thus, one major factor which affects fleece type is the number of secondary follicles in a group through its effects on fleece density and the size of the fibres grown.

However, in a coarser-wooled sheep, the fibres in a staple are not all the same size; they show considerable variation. In particular, some are longer and coarser than others. This is because the primary follicles are larger than the secondary follicles. In general, the earlier the follicle is formed, the larger it is. In fine-wooled breeds, the initial primary follicle is itself small, so that the subsequent secondaries are not very different in size. However, in coarser-wooled breeds, the primary follicles become very much larger than the secondaries. In other words, as the primary follicle size increases, so does the ratio of the size of primary follicle to the size of secondary follicle. In the extreme case of the carpet-wool type, the primaries produce a long, coarse fibre while the secondaries produce a relatively fine fibre. This means that the variability within a staple will increase as the wool type becomes coarser. This variation in diameter, resulting from the ratio of primary to secondary follicle size, is the second major factor affecting fleece type.

The third factor is the amount of raw material and energy reaching the follicle. One measurement of this is the weight of fleece grown. If there is less raw material to be divided amongst the follicles, then a smaller fibre must result. Thus, some 'Down-type breeds have follicle populations similar to the Romney but have lower fleece weights,—*i.e.*, less raw materials, and hence finer fleeces.

Figure 3 summarizes some of the major breed types divided up according to these three main factors—*i.e.*, secondary/primary follicle ratio, the size of primary/the size of secondary, and the amount of substrate. It shows how a change in one of these factors can lead to a change in the type of fleece produced. It should be noted that this is a somewhat simplified picture because these factors can interact with each other. However, if it were desired to change the fleece types, then appropriate selection methods could lead to genetic changes in these factors independently.

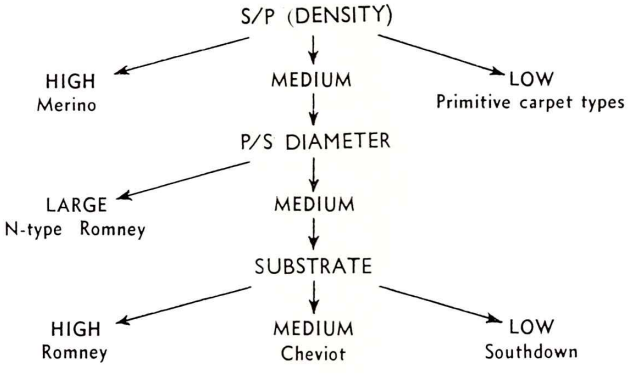

Fig. 3: Factors underlying fleece type.

Thus, to obtain a carpet-type wool, selection for large primary follicles and for fleece weight could be the best approach. This particular case would not, in fact, be necessary as such a sheep is already available. This is the Romney N-type sheep (an experimental sheep kept at Massey College) which produces a good carpet-wool fleece. The basic difference between the N-type and ordinary Romney is that the N-type has larger primary follicles. From this stem all the other differences in fleece type. In fact, research on the N-type sheep underlies much of the knowledge of the factors affecting both it and the ordinary Romney, and because of its research potential, quite apart from its carpet wool, it is probably the most valuable sheep in New Zealand today.

Thus, the basic biology of fleece type is based on differences between follicles and on the whole population of follicles on the sheep. However, there is another complication. A follicle does not produce wool at the same rate all the year round. There is a considerable annual variation in wool growth. In the winter months, particularly June, July and August, only about half as much wool is produced as in the summer months. This annual variation has been studied in detail for Romney shep by Dr D. A. Ross, at Dunedin, who found that most of it was the result of changes in fibre diameter. Figure 4 shows this diagrammatically, with a wool fibre divided up into sections according to the amount of growth in each month. The diameter scale is greatly exaggerated relative to the length.

It can be seen that the big decrease in weight of wool during the winter months corresponds with a big decrease in fibre diameter. Apart from its effect on fleece weight, this thinning of

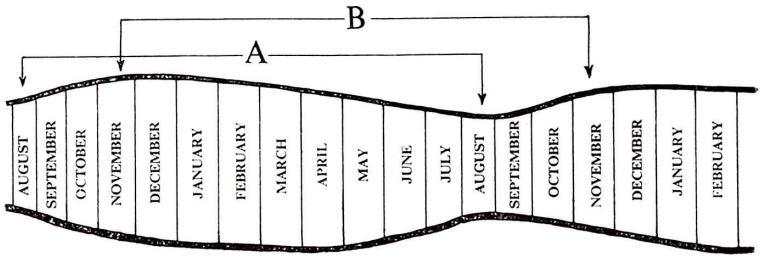

Fig. 4: Seasonal changes in fibre diameter. A—Pre-lamb shorn. B—Post-lamb shorn.

the fibre means that the strength of the fibre is reduced. This can result in poorer manufacturing performance and a greater loss of fibre during carding or combing.

When extreme thinning takes place, then break or tenderness in the fibres results. If fibre breakage occurs while the fleece is on the animal, the fibres become entangled, and cotting may occur. In extreme cases, the follicle will cease growth altogether, and shedding of the fibre occurs. This will also lead to cotting or perhaps to shedding of parts of the fleece.

Both Dr Ross, at Dunedin, and Dr A. E. Henderson, at Lincoln, have shown that tenderness and break are the major faults in New Zealand wools. Together these defects greatly reduce the value of the New Zealand wool clip. Therefore, it is worth considering what is known of the possible causes of this thinning and break of the fibre.

The annual cycle of growth is basic to the sheep and possibly is related to the complete cessation of growth and moulting in animals which do not grow a continuous fibre. This seasonal change may be associated with the annual variations in light and/or in temperature, but there is some discrepancy between the results of experiments so far carried out on these factors.

Work in Australia suggests that various hormones may be implicated. Cortisone, for example, causes a decrease in wool growth, and an excess can cause fibre shedding. Also, there may be an annual variation in the production of cortisone by the adrenal glands. Work on these lines, although of little immediate application, is clearly necessary for the long-term solution of the problem of break.

Apart from the seasonal cycle, the problem is complicated by the fact that the minimum diameter occurs at a time when feed may be short and when stresses from climate and from lambing and lactation occur. These factors will also reduce wool growth and fibre diameter and may act in a number of complex ways. However, from the practical point of view, the important point is that these further reductions occur at the time when the fibre diameter is already reduced, so the fibre is further weakened and there is a maximum chance of break and its associated faults occurring.

Until more is known of the biological causes and the factors leading to thinning of the fibre, there are three husbandry practices to help overcome the problem:

(1) *Shearing before lambing.* This practice results in the fibre being cut at its thinnest point before breakage or shedding can cause a cott. Furthermore, the resulting fibre is much stronger compared with later shorn wool which will have the thin weak part about a third of the way up from its base. This means that pre-lamb shorn wools are superior in performance all the way through the manufacturing process, producing less waste and also a stronger final yarn or cloth. An important point to be considered is the effect on the sheep and its subsequent production. There is little detailed information on this aspect but it is known that shearing can have profound effects on the metabolism and physiological functioning of the sheep.

(2) *Adequate feeding in the period before lambing,* and this means quality of feed as well as quantity. As the foetus has the priority for the available nutrients, only the excess will be available for wool growth and this must be sufficient to prevent break.

(3) *Suiting fleece type to the country.* As a large follicle producing a coarse fibre needs more raw materials and energy to maintain it, under these stress conditions it will show a greater absolute reduction in fibre diameter. Thus, a sheep growing a coarse wool needs better conditions than a sheep growing fine wool if it is to produce a fleece free of faults. This emphasizes the necessity of suiting the fleece type to the country. Trying to grow a strong fleece on poor country usually results in a light fleece with many faults in it.

Other wool faults, on which some interesting work has been done by Drs I. E. R. Fraser and Henderson, at Lincoln, are fleece rot and fleece staining. Figure 5 shows the chain of events that

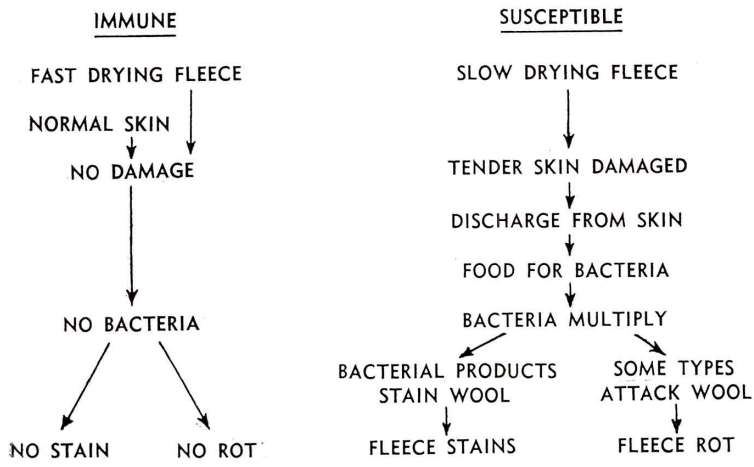

Fig. 5: Factors underlying bacterial staining of the fleece.

they have discovered. First, there are two types of Corriedale sheep, one of which is immune to fleece stain and the other susceptible to it. The immune type has a whiter fleece with a softer handle than the susceptible type but no measurable differences have been found between the two types of wool. After wetting, the susceptible type of fleece stays wet longer than the immune type. In addition, the sheep with such a slow-drying fleece appears to have a more sensitive skin than the quicker-drying type. These two factors lead to skin damage and the formation of an exudate or discharge from the skin. This exudate provides food for bacteria and offers ideal conditions for their growth. These bacteria excrete the coloured substances which cause the stains in the wool. Other types of bacteria may actually attack the wool, leading to fleece rot. The basic cause, however, is the ideal conditions for bacterial multiplication caused initially by the damp conditions and the skin damage.

It may well be that these differences in skin susceptibility have some genetic basis, in which case bacterial damage might be reduced by culling those sheep which show such damage in their fleeces.

The final point in this discussion is the biological basis of fleece weight. The factors which can contribute to fleece weight have already been discussed—*i.e.*, the number of follicles, their size, and the amount of the substrate of raw materials and energy available to them. Selection experiments on Merino sheep in Australia would

suggest that these factors can be varied independently. For instance, if increased fleece weight is selected for, while, at the same time, fibre diameter and body weight are held constant, an increase in fibre number and fibre length results. This is an important conclusion for breeders of fine-wooled sheep because an increase in fleece weight without an increase in diameter is what they require. If selection for fleece weight alone were practised, it seems likely that the increased weight would result from increases in body weight, fibre diameter and fibre length. As another possibility, it has been noted that the N-type sheep differs from the ordinary Romney in that some of its fibres are greatly increased in diameter and length, while other fibres are shorter and finer. In this case, the overall effect is of only a very slightly increased fleece weight.

In other words, the changes in fleece type which will result from selection for increased fleece weight will depend on how this selection is carried out. It would seem likely that it is possible to obtain almost any combination of factors which may be required if the appropriate basis and method of selection can be discovered.

The nutrition of the sheep may also change the fleece. In general, the effect of better feeding on the adult sheep is to increase both the diameter and length of the fibre in proportion to the relative sizes of the follicles. With better feeding throughout the life of the animal, the situation is more complex as the nutrition of the lamb can affect the development of the follicle population.

Clearly, if the fleece can be varied in this large number of ways, the factors underlying fleece weight must be complex and there must be a number of differing pathways whereby fibre growth may be limited or increased. With Romney sheep, which are also required to produce fat lambs, the additional problems of fertility, milk production and lamb growth must be considered in relation to changes in fleece type and fleece weight. It is on this aspect that New Zealand needs to make its own way in sheep research, as Australian work is mainly concerned with the wool aspects of sheep production.

Figure 6 summarizes the major factors underlying this problem. Starting from the bottom of the diagram, the properties of the completed wool fibre will depend on the raw materials and energy supplied to the two main types of follicle and on the inherent size of these follicles. Secondly, there is the distribution of the raw materials and energy. These are required by the sheep for many things besides wool growth—*e.g.*, maintenance, body growth, preg-

nancy, and lactation. Cases are known where these other functions have priority over wool growth. Thus, growth of the foetal lamb has priority over the wool production of its mother.

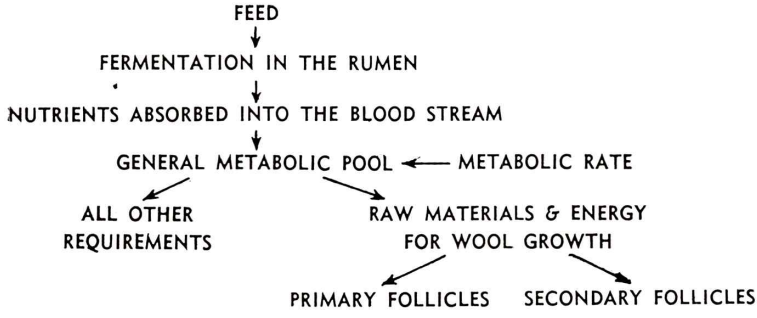

Fig. 6: The factors underlying fleece weight.

As already mentioned, stress can lead to reduced production and a break in the fibre. This may well be because the energy is required elsewhere and is switched by the appropriate mechanisms from wool production to another use which at the time is more important for the sheep. Some of these mechanisms are beginning to be understood, and it is probable that hormone actions are important.

Thirdly, consideration must be given to the total supply of energy and raw materials before they are divided up. These will depend on the metabolic rate of the animal—*i.e.*, the speed with which it turns the nutrients into energy and the required raw materials, and the supply of these nutrients absorbed into the blood stream. The supply of these nutrients, in turn, will depend on the reactions or fermentations in the rumen and finally on how much and what the animal eats.

Thus, the factors underlying fleece weight are complex and they have been reviewed here to emphasize that wool growth problems and, in particular, those concerned with fleece weight cannot be divorced from other aspects of the sheep. To a large extent the fleece obtained will depend not on the skin but on the animal inside the skin.

Three main topics have been discussed in this paper to show how research on the biology of wool growth can impinge on various problems. They are.

(a) The follicle population, follicle types, and their bearing on the type of fleece produced.

(b) The variations along the fibre and how they can result in break and other wool faults.

(c) The sort of problems which are associated with increasing fleece weight.

At a time when the future of wool is coming in for considerable discussion, it is of interest to see how knowledge and research on wool biology relates to other fields of work which should be undertaken to ensure that New Zealand continues to ride on the back of the sheep.

The main factors concerned in the sale and production of wool have been summarized in Fig. 7. The final limiting factor is the sale of the finished product. If the manufactured woollen goods are not sold, production problems become unimportant. However, if the present promotion plans of the International Wool Secretariat are successful, then, as long as the overall economic situation is satisfactory, presumably sales will increase.

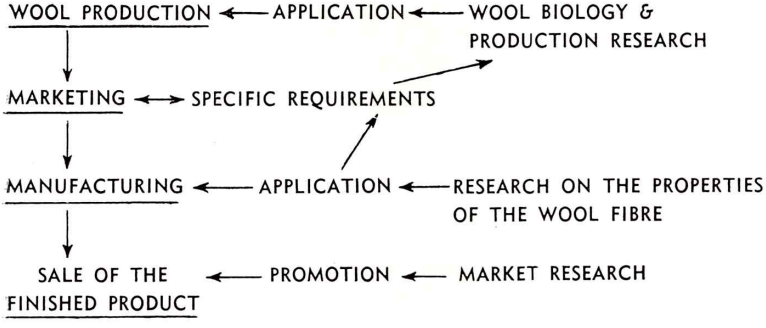

Fig. 7: Relation of research to the production and sale of wool.

Such success could pose two problems which would concern wool biology. First, to find methods to increase production of wool to cope with the increased demand if this demand shows any signs of outstripping the supply. Whether this will occur is basically a problem for economists but one which should be anticipated by biological research which is of necessity long term in nature.

Secondly, particular types of wool may be in demand and it would be necessary to know how to produce them. For example, it is possible that there will be a rising demand for carpet wools. In this case, already a considerable amount of information is available, from work done with N-type sheep, on methods of breeding for carpet wools of different types. There are, however, many unsolved problems on which work would be required.

The next stage to consider is that of wool manufacture. Research advances in the study of the wool fibre have resulted in the "Siro-set" process, shrink-proofing, moth-proofing and quite a range of those properties which formerly were the sole prerogative of synthetics. As more research is done on the physical and chemical properties of the fibre, it can be expected that there will be further advances at the manufacturing stage which should lead to a greater demand for wool. Hence, they are to the farmer's advantage.

However, as these advances are made and as more is known about the wool fibre, and as more can be done with it, then so may the requirements of the manufacturer become more technical. He could, for example, require wools of certain minimum sulphur content, or some other specific chemical or physical property. This in turn would mean some changes in the present approach to production and could require a considerably increased knowledge of methods of producing wool to specification. It also implies some changes in marketing.

This type of approach may take many years to come. But, if wool is to compete with synthetics, then, like the big chemical combines manufacturing synthetics, the people interested in wool must anticipate the problems and obtain answers to the problems before they arise.

There is one more point in Fig. 7. Research and sales have been discussed, and it has been indicated how they may be inter-related, but research is of no use unless the results are applied. The Australian methods such as Siro-set, although available and publicized, were not taken up very quickly by manufacturers. There is little that producers can do about this except through their producer boards.

However, the producers can do something about ensuring that technical advances are applied quickly in their part of the industry. The very nature of wool growing puts it at a disadvantage with the synthetics industry, because sheep production and sheep breeding are a slow business and are necessarily dependent on indefinable things like stock sense. However, there seem to be many simple technical advances which take a long time to be applied.

An illustration is a simple breeding practice previously suggested at Massey College sheepfarmers' meetings, namely, selecting for open-faced sheep. If arbitrary figures of 50s. for a lamb and 5s. per lb for clean-scoured wool are taken, a difference can be estimated for a 1,000-ewe flock on a yearly basis. This comes to £737 per year in favour of open-faced ewes, as a result of their weaning 26·5 per cent. more lambs, and clipping annually 0·3 lb more clean-scoured wool than wooly-faced ewes as have been shown on average for each of the four years that woolly and open-faced sheep have been compared in the face cover research flock.

Assuming 20 million woolly-faced sheep, which might have been open-faced if this simple breeding practice had been vigorously adopted by the nucleus studs, the country may be losing up to £14 million a year. A small difference per sheep can mean a large difference on a national basis.

However, notwithstanding face cover, the fact remains that in the competition of wool with synthetics the answer lies, not just with the various facets of research and with wool promotion, but also with the farmer, the stud breeder and the extension services, in the application of new biological knowledge.

DISCUSSION

Q:: *Is there any further information on the genetic antagonism between fleece weight and fertility of Romney ewes?*

A:: The genetic antagonism referred to in the question is shown by the tendency for ewes which are above average in fleece weight to produce daughters which are below average in lamb production. This antagonism between the two characters was discussed in the *Sheepfarming Annual*, 1954, p. 158. Further work has been undertaken over the last few years in an effort to obtain a fuller understanding of the relationships between fleece production, lamb production, and growth in sheep but no results are available.

Q:: *Are fine-skinned sheep in general more susceptible to bacterial fleece staining than thicker skinned individuals?*

A:: There is no information available on the skin thickness of sheep in relation to susceptibility to bacterial staining.

Q:: *Is there any relationship between "tippiness" in wool and bacterial stains?*

A:: Susceptible sheep may have close, compact fleeces or open fleeces with pointed tips. Tippiness, as such, therefore does not appear to be important.

Q:: *Is the adverse effect of a woolly face on ewe fertility eliminated by shearing two-tooth ewes at the start of mating?*

A:: This is not known at present but it could be an experiment of interest.

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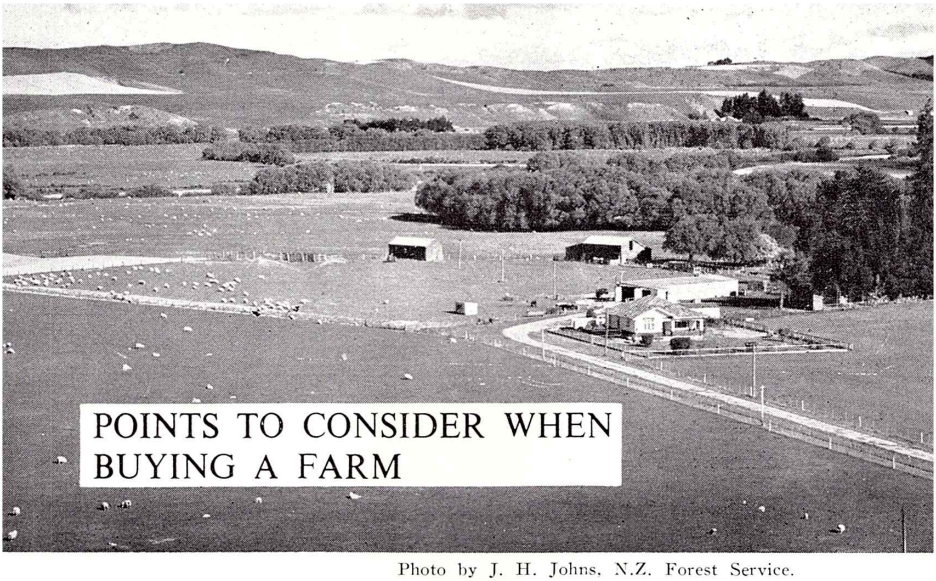

POINTS TO CONSIDER WHEN BUYING A FARM

Photo by J. H. Johns, N.Z. Forest Service.

P. A. MACGILLIVRAY*

FARM FOR SALE

A unique opportunity for the right man. This farm is capable of great development. Present carrying capacity . . .

LAST YEAR, about 4,000 persons bought farms which might have been similarly described. It will already be apparent to some that they have made a good decision and to others that they might have done better.

The buyer's problem is to select one farm from all those available, decide what it is worth to him and arrange for the necessary finance to purchase it. In the case of a man using his savings to buy his first farm, there is a lot at stake. For the man who is selling one farm and buying another, the correct timing of the two transactions is difficult to assess.

When a man buys a farm he buys land and improvements. The improvements include things which he can see, such as buildings, pastures, yards and fences, water supply, trees and tracks. They also include other things which he cannot see, such as clearing, fertility and drainage.

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However, these things do not constitute a farm. Other inputs such as labour, livestock, machinery and managerial skill combine with land and its improvements to make up a farm. Here lies the difficulty for the purchaser of land and its improvements. He must disentangle their contribution to production from that of the other inputs, for example, managerial skill. Many persons have bought land at a price judged on its previous production, only to find later that an important contributing factor to such production was the superior skill of the previous owner. Such production might also have been due to the use of more labour, better machines and better livestock.

Since it is the land which he is buying, it is the land he must value. Reliable and relevant information regarding this major decision is not easy to get. In few other situations is the collection and sizing up of information so difficult as when buying a farm. Despite this, it is vital that the buyer should go to considerable trouble to find out all he can about the farm for sale. Most prospective purchasers have little, if any, experience in buying farms, so it pays them to seek assistance from those who have benefited from such experience. Successful farmers who may have participated and taken a keen interest in buying farms, managers and field advisory officers of the various service and lending organizations, some farm accountants, solicitors investing money in land, may all give useful information. Their counsel in a general way as well as on specific points about the farm under consideration can be invaluable. Private valuers can be employed to estimate the current market price. The land market is not well organized and a prospective purchaser might well find a farm through contact with some of these people. He must, of course, not appear over-enthusiastic in his willingness to buy. The county valuation roll provides the most recent Government value (which may be up to five years old) divided into improvements, unimproved value and capital value. It also gives the legal description, the correct acreage, and the annual rates of the property. A solicitor, or the farmer himself, on payment of a small fee, may search the title of the property to find out its history regarding sale prices, dates and owners and also what commitments are held against the property. The title also carries an accurate, small-scale map of the place.

The sort of knowledge he requires about the farm includes the following seven points:

(1) *What has been the previous production for the place?*

The vendor and his selling agencies may provide factual information on this. Less reliable and sometimes misleading information can be obtained from other people. A thorough inspection of the property, preferably accompanied by someone fully acquainted with other sales in the district, is a necessity. Such an inspection carried out on only one day can be misleading even if the vendor has done nothing to affect the appearance of the improvements and feed position.

(2) *The apparent ease or difficulty with which the stated production has been obtained.*

The benefits of high production may be reduced if the annual costs of obtaining it are also high. Such items as large fertilizer requirements, costly amounts of winter feed or expensive pasture renewal commitments are some obvious ones. In this connection the following comment is made. Naturally fertile land has traditionally commanded a superior price. Under the present state of technical knowledge, the premium appears to be less justified now than previously. Only if one is willing and able to cash in on this higher, natural fertility by diversified methods of farming is the higher price warranted. Technical know-how has reduced the difference in productivity between naturally high and low fertility land. The induced soil fertility and increased stock carrying capacity of such previously poor areas as the pumice country, the light plains land of Canterbury, and the high altitude tussock country support this contention. However, there is land which is so low in fertility that it is better avoided.

(3) *Natural hazards.*

The frequency of major floods, the severity of droughts and the incidence of winter storms and snow risks could have some bearing on the desirability of the area. On some soils the risk of erosion is a real one. The capacity of farms to cope with any of these hazards will vary. For instance, a very flat farm in a flood risk area is obviously more vulnerable than one which includes a piece of higher ground. Similarly, some heavy swampy land in an area prone to drought can be an advantage.

(4) *Conditions and adequacy of the improvements.*

Some improvements, such as the pastures, water supply and fences, are vital. During the inspection the prospective buyer should pay particular attention to these. If any are absent or in poor condition he must keep this in mind when deciding on his price.

Other improvements may not be so necessary; hay barns and bulldozed tracks, for example, can be done without. If money requires to be spent on some of these items immediately he should be able to see where it is to come from. The homestead is a special case, and whether its condition is satisfactory or not is purely personal. However, once a farm is purchased, available money appears to be used on the farm rather than the house so plans for early alterations are often deferred indefinitely.

(5) *State of development.*

For one class of buyer—the man using his own savings—there is a tendency to buy smaller places in a state of poor development. This is probably the worst combination for such a purchaser with limited cash. Two things are important when purchasing a farm requiring much development, (a) the total cost of the job, and (b) the delay before a cash surplus is obtained.

It is essential to get reliable information on the costs and techniques involved in handling second growth such as gorse, manuka, fern or sweet-briar. As well as the money required to get rid of the second-growth, additional finance is necessary for fencing, regrassing, water supply, fertilizer, and stock to graze the developed area. Apart from the difficulty of borrowing money to help buy the land in the first instance, the farmer will have great difficulty in raising finance for development with such poor security. In some cases the Marginal Lands Board may help, but this cannot be counted on when buying a farm. Often the only alternative is to watch the value of the asset decline with the unhampered growth of scrub. It should also be remembered that the owner of such a place is running a great risk in the case of an accident which may prevent him doing the work himself and necessitate finding and paying labour.

(6) *Locality.*

With better roading, wider electrical power reticulation, increased mail and transport services and primary school buses, some of the worst disadvantages of living farther out in the country have been reduced. Where this is the case the writer is of the opinion that the premium paid for land close in to town is less justified today than previously. However, some buyers justifiably pay for this locality value. Those who are changing one farm for another, especially when selling a place farther away from town which they may have developed, will pay a premium. Their requirements for secondary schooling facilities, and the supply of good labour coupled with the desire for a less strenuous type of farming, may

justify this premium. Good locality may also affect the readiness with which a farm can be resold.

(7) *Special features.*

Since a farm also provides a home, there may be things unrelated to financial gain which the farmer and his wife take into account. The layout of the grounds, the nearness of friends, the climate for health reasons, are things which have influenced some buyers.

Apart from these seven points concerning previous production and the costs involved in getting it, natural hazards, condition of improvements, state of development, locality and special features, the questions of tenure and size of farm are important.

(a) *Tenure.*

Although the majority of farms are freehold propositions where the purchaser buys both land and improvements, some leaseholds are available. With Government leasehold properties, chief of which is the 33-year renewable lease, the purchaser does not buy the land, he buys only the improvements. Such is the demand for land at present that where a lease has still a long term to run, say 20 years, no discount is given to this in the purchase price. Lending agencies may reduce their limits of lending by the amount of the lessee's interest. This usually approximates the unimproved value of the land. Hence, if a buyer has to borrow money, it may be no advantage to acquire a leasehold property.

(b) *Size of farm.*

There is a lower limit to size of farm beyond which a purchaser must be cautious about going if he intends to get all his income from the farm. Small, uneconomic farms and pieces of land all have a place if they are supplemented by other income. They often serve as stepping-stones to a farm, as do short-term cash leases or share-cropping agreements. The man with limited cash may be better off with a small piece of land and some additional income from contracting work than his counterpart on a larger piece of land in a state of poor development.

A totally different type of problem which affects the success of the venture also exists, that is, circumstances beyond the buyer's control. Luck or chance perhaps. This really concerns the question of when to buy. Many buyers are advised when not to buy, but this is usually based on experience in some other set of circumstances which may not apply. The man who has enough money to consider buying a farm may be affected by these circumstances whatever he does. Thus, buy when ready, rather than when times

are judged to be right. Current circumstances beyond the control of the individual farmer include existence of and entry to overseas markets resulting from war, political bargaining and inspection standards of different countries. Within the country, unforeseen changes in Government policy may affect the farmer either directly or through secondary industry. Several periods of prosperity and adversity are beyond the control and ken of the individual buyer.

Apart from things concerning the farm itself which can vary and affect its value, there is another consideration. For any one farm, different people will be prepared to pay different prices. That is, purchasers vary as well as farms. Thus, it is quite meaningless to say a farm is worth a certain figure. Its worth will vary according to the preferences and finances of the purchaser. A young man with plenty of enthusiasm and the capacity to work long, hard hours will put a different value on a place from that of an established farmer changing farms to get less work and better amenities. Its worth will vary according to what else will be run in conjunction with it, for example, a contracting business or another piece of leased land. Its worth will also vary according to the use to which it is going to be put; for example, fat lamb production versus stud sheep and cash cropping.

The buyer can calculate what it would be worth to him. He can draw up a thorough estimate of the expected receipts and expenditure under his own management. This compels him to do some hard thinking about the output he is likely to get and what inputs he will have to apply to get it. Mistakes in the future prices which he attaches to such inputs and outputs are not serious as they will apply equally in the case of each farm he considers. He is trying to select the best farm offering, he is not trying to put an absolute value on any one farm. From such an estimate the difference between receipts and expenditure is the net income. The net income is available to meet the cash required for his own drawings and taxes. The balance is available to meet depreciation, and interest on his own money invested. Actual cash, of course, will not be set aside for either of these. Instead it will be used for development and to repay borrowed money, each repayment increasing his own equity in the business.

If the net income is insufficient to meet the charges of personal drawings, taxes, depreciation, and interest on own money, then the farm is too small, too poor, or too dear.

One reason for the present high price of land is that buyers reduce the reward to their own labour, management and money invested in order to justify the price of the land. Although the net

income from the farm selected may not adequately meet those charges which have been discussed, the farm may still be bought. This means harder work, less money in his pocket, and less return on his money invested for the buyer who wishes to have the privilege of owning a farm.

An Example

The case of a farm which was recently sold at £28 per ewe equivalent, or £112 per acre, 250 acres freehold, 10 miles from town and railhead could be considered. Carrying capacity is 1,000 mixed-age Romney ewes (buying in two-tooth replacements and selling after four lambings), 30 Southdown rams, plus killers. Fifty weaner steers are bought and wintered and then sold fat at about two years of age. Lambing percentage is 100, and 10 lb of wool is produced per ewe. Ten acres of choumoellier are grown for winter feed and this crop is followed by new grass in the spring.

The estimated annual income and expenditure from this property are given in Table 1, and result in a net income of £1,500.

TABLE 1: Estimated Annual Expenditure and Receipts

Estimated Annual Expenditure	£	*Estimated Annual Receipts*	£
Stock purchases	2,045	Wool	1,660
Wages	70	Sheep (total sales)	2,368
Manure and seed	270	Cattle (total sales)	1,618
Tractor fuel and oil, car expenses	100	Sundry	20
Cartage and contract baling	110	Total receipts	5,666
Shearing, crutching, dipping	110	Less expenditure	4,166
Electricity	40	NET INCOME	1,500
Farm stores	100		
Insurance	25		
Phone, mail, accountancy	40		
Repairs and maintenance, buildings, plant, drainage, fencing, water supply	270		
Rates	100		
Interest on borrowed money:			
Land (see Table 2) £14,000 at 5%	700		
Stock, plant, working capital, £3,100 at 6%	186		
TOTAL EXPENDITURE	4,166		

This net income of £1,500 is available to pay in cash:

	£
The owner's personal drawings, say, £12 per week	624
The Income and Social Security taxes which must be met (assume married with three children)	180
	804

This leaves £696 to cover depreciation on buildings and plant, say £150, and the balance of £550 to allow interest on his own money invested. This gives about 3½ per cent. interest on such money. No allowance has been made for development or repayment of borrowed principal.

The amount of money involved and the proportion borrowed for the farm in question is shown in Table 2.

TABLE 2: Costs of Ingoing

	Borrowed	*Own Cash*	*Total*
Land and improvements	14,000	14,000	28,000
Stock	2,000	1,500	3,500
Plant	500	300	800
Working capital	200	100	300
Legal and ingoing costs	400	100	500
	£17,100	16,000	33,100

Arranging Finance

Money for the purchase of land is available on mortgage with the land as security and a personal covenant to repay. In the case of table mortgages, principle is repaid annually as well as interest. Thus, at the end of the term, the whole debt has been repaid. Flat mortgages, on the other hand, require only the interest to be paid each year, and at the end of the term the total amount borrowed is repaid in one lump sum.

The State Advances Corporation, the biggest land financing agency in the country, lends on table mortgage at 5 per cent. rate of interest. Solicitors lending money held in trust accounts, some savings banks, some insurance companies and trust companies, are other sources of finance for land. The vendor is the other main source of money for the purchase of land. Half the amount of the

purchase price and occasionally more may be obtained in this way. However, the more money that is left, the higher the sale price is likely to be. Normal margins of lending on land are from half to two-thirds of the market value. Rates of interest are from 5 to 6 per cent.

Money for the purchase of stock and plant can be obtained from the stock and station agencies, the banks, the State Advances Corporation, or solicitors. Normal margins of lending on stock are about 50 per cent. but these may be raised according to circumstances. Rate of interest is 6 to 6½ per cent.

Borrowing money is a strictly individual operation. The total amount lent, the terms of repayment and the margins of lending vary from case to case. Lenders are interested in the person to whom they lend and the security on which they lend, in that order.

The total amount of money which a buyer can assemble is the most important consideration when contemplating the purchase of a farm. In this connection the prospective buyer should aim at getting experience in handling borrowed money. He can get to know about sources of money. He can get experience in bargaining for money, conditions of lending and terms of repayment. He can build up his credit worthiness by adhering strictly to the repayment conditions. If he is borrowing money in connection with a small farming enterprise, he can also demonstrate his farming ability to the lender. In farming today borrowing money should be regarded as a business rather than as a favour.

In addition to the money required for land, stock and plant, the buyer also needs working capital. His own living expenses, shearing costs, spring topdressing and seed, mortgage charges and rates are some of the items he may have to pay before money starts coming in.

Legal and ingoing costs must also be provided for. These will cover stamp duty, solicitors' scale fees, fees for arranging a mortgage, and a registration and search fee. This can be paid in cash or included in the overdraft for working capital at the bank or mercantile firm.

Due consideration should be given at the time of purchase to ownership of the farm. This is the time to decide on companies, trusts or partnerships.

DISCUSSION

Q:: *Would the speaker please explain how the profit of £1,618 from cattle was calculated?*

A:: This is the total receipts from the sale of cattle, not the trading profit from the cattle account.

Q:: *Is the example farm considered to be an economic proposition?*

A:: For the man who bought it, obviously yes. However, for a place with the production of this one, I consider the price to be high.

Dr. P. D. Sears:: The budget given does not disclose the true position. To the 3½ per cent. return shown on invested capital would have to be added a figure of approximately 4 per cent. for the annual depreciation in money value owing to inflation which would occur if the money was invested in, say, the Post Office Savings Bank.

Q:: *Much land is sold at public auction; can any comment be made on the points to be taken into account?*

A:: The bidder should have arranged beforehand the absolute financial limits to which he could go. Without this he might well fail to purchase by a small amount which could possibly have been arranged satisfactorily. Also, if the property fails to sell at auction, the highest bidder gets preference in subsequent negotiations.

Q:: *In the example, £17,000 was borrowed. What amount would be required to pay this back?*

A:: £1,360 per annum would repay this amount in 20 years at 5 per cent. rate of interest.

Q:: *Would the speaker care to give what he considers to be a reasonable price per ewe equivalent to pay for land today? Does he consider the £28 per ewe equivalent paid in his example to be too dear?*

A:: Farms can be bought today at reasonable prices. Prices for these are in the following ranges: fat lamb farms about £25 per ewe equivalent (not including cattle); good store hill country farms about £18 per ewe equivalent; poorer and larger hill country farms less than £10 per ewe equivalent.

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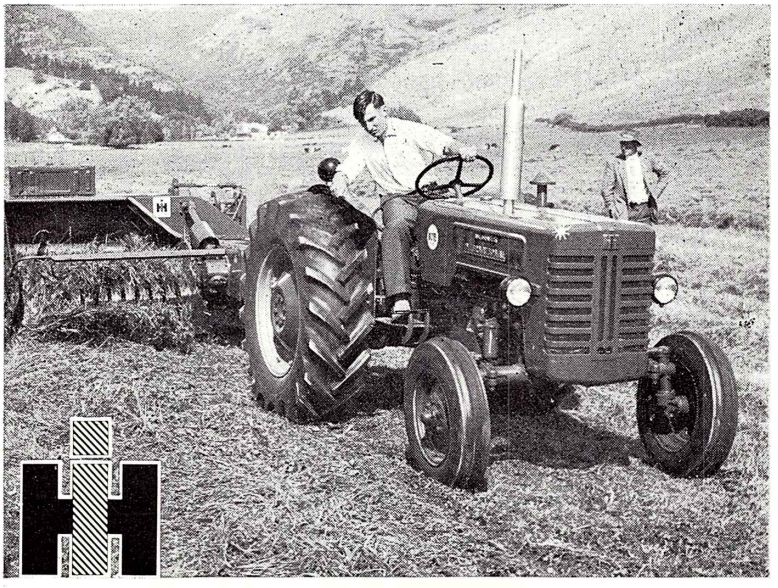

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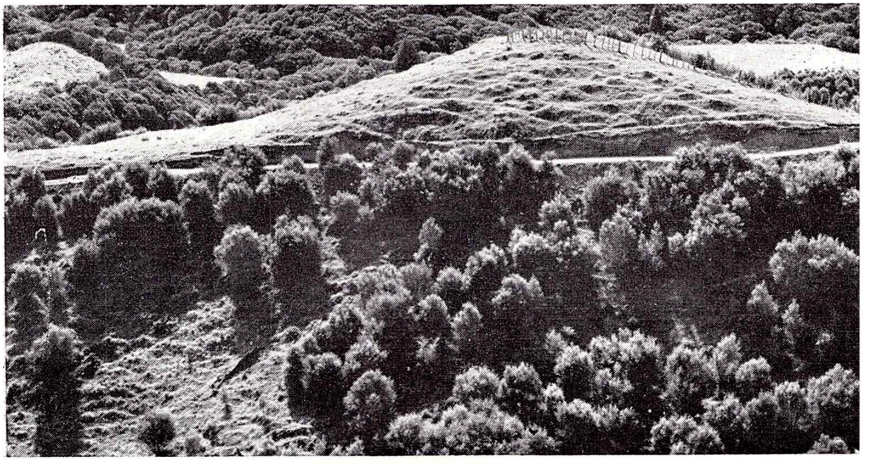

Photo by J. H. Johns, N.Z. Forest Service.

THE PROBLEMS OF UNDEVELOPED HILL COUNTRY

WITH PARTICULAR REFERENCE TO THE EAST COAST

E. M. SMALL*

THE PURPOSE of this paper is to discuss the problems associated with the development of second-class hill country, with particular reference to a large area lying inland from the east coast of the Wairarapa.

The problems in this area are, however, substantially the same as those associated with a very much larger area throughout the grassed hill country of New Zealand.

There are two aspects of development. The first is physical and concerned with the eradication of pasture weeds; or the improvement or the replacement of existing pasture species with more productive ones; and the provision of sufficient animals to graze the improved pastures efficiently.

The second aspect is a matter of finance—that is, the money to mobilize the resources of materials, labour, and livestock to carry out the work. It is the first aspect of the general problem that is the primary concern of this paper.

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Typical of the area under discussion are the hills contained within the counties of Masterton, South Wairarapa, and Featherston; for the purpose of this paper, they will be referred to as the Wairarapa hill country.

The hills are big but of easy to steep contour and about 30 per cent. of them are cultivatable with giant discs. With few gorges or very steep sidlings, they are relatively safe for beef breeding herds. This is in contrast to much of the hill country on the west coast of the Wellington province which is very steep, often dissected into gorges and thus a death trap for cattle, especially when feed is scarce.

Soils of the Wairarapa

Apart from the fertile limestone hills of the Maungaraki Range, outcrops of calcareous mudstone, and a considerable area of rubbly greywacke, the soils are of medium to very poor fertility.

The poor soils of the Wairarapa hill country fall into four main types:

The poorest of these are derived from argillite. The original vegetative cover was beech forest, manuka (*Leptospermum scoparium*) and some open areas of naturally established danthonia. These soils are droughty, especially where the parent rock comes close to the surface, and are slow to improve, even under good management. Their present pasture cover is danthonia, sweet vernal dominant, with some brown-top on the shady country. Clovers are almost absent. The drier areas revert slowly to stunted manuka and heather (*Ericaceae* family) while the shady sidlings and gullies revert quickly to manuka scrub and, where the soils are better, to tauhinu (*Cassinia leptophylla, C. vauvillierssi*).

An argillaceous sandstone in association with a poor mudstone forms the parent material of the second soil type. The sandstone country was originally covered predominantly with beech forest, and now manuka is a serious invader. Pasture response to fertilizers is slow. Where the mudstone appears, the soils and pastures are better, but so too is the manuka, especially on the shady country.

The third soil type is a greyish brown silt loam of medium to poor fertility derived from a soft mudstone. Of easier contour, it becomes very soft during wet seasons and is difficult to drain. Originally covered with light bush, kanuka, toi-toi, and cabbage trees, the best of this country holds a fair pasture of danthonia,

sweet vernal, and crested dogstail with some clovers on the better areas, but the pastures on the poorer soils tend to be brown-top dominant and revert readily to manuka.

Typical of the fourth of the poorer soil types is a broad strip of flat and rolling to easy hill country lying north from Te Wharau.

A clay loam on sandstone, this is a cold wet soil. The pastures are brown-top dominant, and clovers are absent. It reverts readily to manuka; and gorse (*Ulex europaeus*) introduced originally as a feed for sheep, is now a problem. Fortunately an easy contour permits most of the area to be cultivated, and first-class ryegrass-dominant pastures are being established with the aid of drainage, phosphates, and lime.

Climate of the Wairarapa

The Wairarapa climate on the whole is excellent for sheep farming but drought conditions occasionally prevail. A rainfall which varies from about 38 in. inland to 45 in. on the coast, is distributed with reasonable evenness throughout the year.

On average, 3 in. per month falls between December and May, 5 in. per month between April and September, and 3½ in. per month from August to January. The moisture retained by the hill soils of the Wairarapa is, however, greatly reduced by the amount which runs off the hard, dry topsoil and by the drying effect of the prevailing westerly wind.

Twenty-five per cent. of the wind blows from the east and south. While these winds are very beneficial in the amount of rain they bear, the southerlies and south-easterlies frequently reach gale force and, when accompanied by rain and lower temperatures, can cause high death rates amongst young lambs and shorn sheep.

Temperatures are, on the whole, mild. Some growth occurs throughout the winter over most of the area. Mean daily minimum/maximum temperatures range in January from 50° to 74° and in July from 35° to 53°.

The hill country is subject to light frosts only, but in the inland basins and valleys some 30 to 55 frosts per annum are recorded.

The Condition of the Land

The total area of occupied land in the three counties considered is 1,132,000 acres, of which approximately one-third is classified as unimproved and, in the main, unproductive. It has been esti-

mated that over 100,000 acres of potentially good grassland has reverted to manuka, tauhinu, heather, and gorse. A visit to the area would suggest that this is a conservative estimate.

Of a total area of 755,000 acres in grass, 30 per cent. is topdressed annually. Since most of the cultivated land is topdressed regularly, it is obvious that much of the hill land is receiving very little or no artificial fertilizers.

Since 1949 sheep numbers in the Wairarapa have increased by approximately 50 per cent., with a corresponding increase in beef cattle. This increase in stock numbers would indicate that all is well with the hill lands of the Wairarapa and that the improvement of them is progressing satisfactorily. It must be remembered, however, that during the last decade a very large area of flat land in the valley of the Ruamahanga and of rolling country within the hills has been cultivated, cropped, and sown to improved pastures with a high level of production. The increase in stock numbers on this land has undoubtedly masked the fact that numbers have remained stationary, or declined, on much of the medium to poor hill country.

This, indeed, is a common picture on the individual farm where there are many instances of development proceeding to the limit of available finance on the cultivatable portion of the property, while manuka scrub and tauhinu spread and close in upon the pastures of the steeper hills. On some properties the reversion of the steeper country has kept pace with the improvement on the cultivated areas so that stock numbers have remained static.

Undoubtedly the fastest way to increase the production from poor soils is to destroy the old pasture by cultivation and establish instead a sward of improved species; the resulting increased carrying capacity justifies the method. Nevertheless, if, as a result, the scrub infested, steeper portion of the farm is neglected, it may finally become uneconomic to develop. It is the need to save this country that inspired this discussion.

Methods of Development

Before proceeding to describe methods by which the land can be developed, the importance of providing conditions for adequate pasture control with grazing animals should be stressed. The size of paddocks, the location of fences and water supplies must be taken into account.

The Size of Paddocks

The size of paddocks is important only in relation to the effectiveness of grazing management. The aim should be to make them no greater than the largest mob of sheep can graze evenly when rotationally grazed, or that will allow effective pasture control with cattle.

Fencing

Fences should be located to separate the shady country from the sunny faces where practicable. The pasture on shady country is less palatable and in large paddocks tends to be neglected, while the sunny faces are often over-grazed. Also, manuka flourishes on the shady country so the grazing management of it is important.

On steep country the fences should be located on the ridges and round the head of gullies so that the shape and contour of the paddock gives a natural lead for the stock, and particularly cattle, to move around and graze the faces evenly.

Fencing, however, is expensive and the economics of developing second-class hill country do not warrant the expenditure of large sums on it. A post and wire fence, built to a good standard, costs between £900 and £1,100 per mile on steep hills. By contrast an electric fence capable of controlling both sheep and cattle can be erected for from £150 to £200 per mile. The saving in cost by using an electric fence would be better invested in pasture improvement.

Water

An improvement in pasture production assumes an increase in stock numbers; therefore an adequate water supply must be provided.

On steep hill country, water supplies located towards the top of ridges and the head of gullies attract cattle and as a result the whole paddock is grazed more evenly.

Access Tracks

If the area under development is to be adequately serviced, access should be provided in the form of farm tracks. Properly located tracks not only simplify the transport of farm materials but, on rugged country, greatly facilitate the movement of stock because of the lead they give to a mob. Farm tracks also tend to lead stock on to country that otherwise would not be grazed

efficiently. The per-acre cost of tracks depends upon the total length, the configuration of the land, and whether the work is done by contract or with the owner's plant and labour. Sufficient roading on steep country amounts to approximately half a chain per acre, and the contract price to about 15s. per chain. Thus the total cost could be 7s. 6d. per acre.

Development of Cultivatable Land

Since the advent of the heavier type of crawler tractor during the 1930's, agricultural machinery and techniques have been developed to deal efficiently with the various soil types and pasture weeds which occur on the easier contours of hill country. Where weeds such as manuka scrub or gorse occur, the need for a clean burn of the litter is not always appreciated and, as a result, the cultivation is expensive, often not up to standard, and the new pasture is slow to establish.

On light land, where forage crops do not succeed on virgin cultivation, the best crop is grass. On the heavier clay loams which abound in the Wairarapa, a vigorous stand of the sown species is more likely to eventuate if the area remains in crop or fallow for two years before the pasture is sown. This practice allows time for the original pasture to be completely destroyed, the soil and turf to weather down to a fine seedbed, and the benefits of heavy applications of lime to become available before the permanent pasture is sown.

Adequate drainage is also essential before the potential of the new grass can be fully exploited.

Allowing for 30 lb of grass seed and an aggregate of 6 cwt of fertilizer, contract costs range from £20 per acre on the lighter soil types to £25 on the clay loams. In addition, lime and drainage may be necessary on the clay loam soils.

Development of Clear Grassland on Steep Hill Country

Two techniques for the development of this country are available.

The first of these is the method popularly known as chemical ploughing. The existing pasture is destroyed by chemical agents and replaced with a selected mixture of improved pasture species. Technically it can be successful but the high cost of efficient chemi-

cals and their application limits their extensive use. Experimental work aimed at increasing the economic efficiency of chemical ploughing is in progress.

The second method of improving the existing pasture by aerial oversowing with clover seed and fertilizer is well known and has been used successfully on a great variety of soil types and in different climates. Farm advisory officers of the Department of Agriculture are well equipped to advise on the seed and fertilizer requirements of any locality.

The key to success is the establishment and development of a vigorous clover population. Establishment of clover seeds is more certain if the area is prepared by close grazing followed by allowing a short growth of grass to protect the seed from sun and wind. Even so, many seeds may perish and need to be replaced the following year.

The timing of the oversowing with clover seed can be critical to successful establishment. While the autumn appears to be the best season on the east coast, where it is usual to sow both white and subterranean clover, the outstanding results on many west coast properties from white clover sown in the spring proclaim the advantages of this season in districts which are relatively free from summer droughts.

To justify the high cost of fertilizers, the early establishment of a vigorous clover population in the sward is essential. This can be speeded up by a system of grazing which encourages the clovers to seed.

Two hundredweight of superphosphate per acre should be applied with the seed and a further 2 cwt about six months later, when the plants are strongly established; and thereafter not less than 2 cwt per annum for at least two to three years. An aggregate of from 6 to 8 cwt of superphosphate seems necessary before increased animal production can support and redeem the cost of development.

The greatest weakness of most oversowing and fertilizing programmes is the failure to utilize fully the increase in pasture production which follows. Failure to control spring growth, for instance, results in a suppression of clovers and the loss of many plants. Also the very great contribution that a high stocking rate can make to the progressive improvement of soil fertility does not appear to be universally appreciated.

Development of Weed-infested Hill Country

Of the many weeds which infest poor hill country, the most widespread and the most difficult and costly to control are manuka, bracken fern (*Pteridium esculenta*), and gorse. Tauhinu is a problem in some areas, especially in the east coast of the Wairarāpa.

Manuka and tauhinu are unpalatable to stock and soon develop into strong plants which shade and finally destroy the pasture beneath them. They flourish and persist on poor hills, first because the sparse pasture inherent to this land is open enough to permit the seeds to germinate and establish and, secondly, because the income from poor hills rarely provides a large enough surplus to meet the high cost of weed control. On better hills, where management has been good, a dense sward and high production have prevented the establishment of these weeds.

Gorse

Techniques may include firing and cutting, and grubbing; and the use of hormones, and of grass-seed, fertilizers, and pasture management which, though expensive, will finally effect the complete control of gorse. There is little that can be added here to work which has already been published on gorse eradication.

Tauhinu

Tauhinu is a plant with a soft brittle wood which decays quickly in a damp, warm environment. It sets a great quantity of seed which germinate and establish freely in the path of a fire or wherever the pasture is open enough to prevent competition from grass. It appears to prefer the better country though it can be found on extremely poor hills. It should be cut in mid-autumn and left to lie. If the late autumn grass grows up amongst the litter, the decay of tauhinu will be hastened. Subsequent management, including the establishment of clovers and the application of fertilizers, should be aimed at developing a thick sward of grass to prevent the re-establishment of plants from seed.

Bracken Fern

Bracken fern flourishes on the light lands of the higher rainfall areas but is unable to survive the defoliating and tramping effects

of many animals. This is its weakness and how this can be exploited to convert fern country into good pasture was well illustrated by Clarke (1960).

Manuka Scrub

This is the arch-criminal weed of hill pastures. It occurs throughout New Zealand on a great variety of soils but especially on the poorer types where an open sward gives the seed a chance to establish. The total area in New Zealand is so great that it belittles the presence of other pasture weeds. Madden (1940) estimated that 2·5 million acres in the North Island were covered in manuka and, in addition, 9·5 million acres were liable to infestation. Hamblyn (1953) stated that manuka was widespread on 7 million acres in the land districts of Taranaki, Wellington, Hawke's Bay, and Poverty Bay. In the county of Masterton alone, almost 20 per cent. of the occupied land is infested. In the neighbouring county of Akitio, a more accurate survey (Woods, 1951) reported that 22 per cent. of the land was covered or partly covered with manuka scrub.

Attempts to clear the land of manuka in the past have been largely abortive, not only because of lack of finance but because of poorly organized and haphazard methods. In view of its impact on the national economy, it is extraordinary that no scientific study of the plant has been organized to develop an effective and economical method of control. One reason for this lack has undoubtedly been the hope that biological or chemical control of the weed would prove effective.

Biological control with the mealy bug (*Eriococcus orariensis* Hoy) promised complete eradication as it proceeded to destroy most of the manuka on the east coast of the South Island and large areas in the North Island. However, since this species of mealy bug was attacked by a parasitic fungus a few years ago (Hoy, 1961), the recovery of infested plants in the North Island has been as spectacular as the wave of destruction which preceded it.

In view of the initial success of the mealy bug, further investigations into the possibilities of biological control should be urgently prosecuted.

The possibility of using chemical or hormone sprays to control manuka is being investigated. While some success with seedlings has been reported, the older plants appear to be strongly resistant.

Thus this form of attack must be regarded as experimental until more effective and economical materials are developed.

Since manuka first invaded their land, farmers have fought a losing battle against it with slasher and fire. Some land, however, has been cleared by observant practical farmers who, from their experience, have devised techniques which have kept the weed in control. Their methods should be better known.

Manuka is a tough, unpalatable plant that seeds freely and regenerates from the base if the top of the young plant is removed. After flowering, the familiar small fruit or capsule appears, and each contains up to and over four hundred minute elongated seeds. In the late autumn the capsules open and during the next few months the seeds are released.

The seeds may be transported by birds, or in the coat or on the feet of animals; or they may be airborne for considerable distances. The seeds can be destroyed by a hot fire, or the germination and establishment of them inhibited by the shade and competition from a thick sward of grass; but in a favourable environment they germinate within a few days and may reach a height of up to 18 in. within twelve months.

Within three years, seed is again forming on the young plant, and the cycle is complete.

An understanding of this botanical cycle should provide the basis of any plan to clear the hills of manuka scrub. It is abundantly clear that re-infestation occurs mainly from seed, so the attack upon it should be on a three-pronged front:

(1) Prevent seed production.

(2) Reduce the distribution of seed to a minimum.

(3) Create an unfavourable environment for seed establishment.

With these three guiding principles continuously in mind, a plan to eradicate manuka can now be put into operation.

Clearing should begin and progress on the side of the prevailing wind so that a minimum of seed is blown on to the new burns. Every plant must be destroyed together with its seed. Old heavy scrub should be cut during the winter and early spring in time for the wood to dry before burning in summer.

The spring and early summer are the best times to cut light scrub of five to eight years of age. Cutting, ideally, should be done two to four weeks before burning so that the leaves are still pre-

sent to carry the fire. Before burning, the seed-bearing, scattered scrub should be tossed in from the edges of the main block, or heaped, to ensure a clean burn.

None of the old scrub regenerates if the burn is hot and clean, so the timing of it is of the greatest importance. No seed will survive if the ground is dry and the scrub is burnt with a slight breeze during a hot, dry day in January or February.

Ideally, the grass-seed should be sown on the ash of the burn, but if a long, dry, and perhaps windy spell of weather is forecast, it may be better to delay seeding until mid-March when autumn rains will assist germination. Since the time of sowing in relation to the expectancy of rain has such an important bearing on the strike, greater use ought to be made of the Meteorological Service to determine the time to sow.

The seed mixture must be based on clovers and the more productive grasses, for these will persist if properly managed. The inclusion of brown-top and/or danthonia may be warranted, since a complete cover is the aim. In any case, on the harder faces, the production from these grasses in association with clovers may be no less than the better grasses for the first few years.

Where scattered patches of light scrub have been burnt, a seeding rate of 10 lb per acre should be sufficient because a certain amount of the old pasture will regenerate. From 15 lb to 20 lb per acre is desirable, however, on the burn of a large area of heavy scrub.

A minimum of 2 cwt of superphosphate must be sown with the seed and subsequent applications should be frequent enough to achieve a high stocking rate within two to four years.

The management of the new pasture is of the utmost importance, the aim being a dense leafy sward that gives a complete cover in the shortest possible time. Intermittent, light grazing with mobs of sheep during the first few months should develop a vigorous pasture, and, in the spring, sheep and cattle can be lightly set-stocked to encourage tillering and leafiness in the sward.

Little regrowth of manuka will occur if the initial work is efficient. If it is cut at ground level or pulled every two or three years, it produces no seed and the area infested by it becomes progressively less. Should this final phase of work be neglected, and re-seeding permitted, manuka will remain a problem.

The cost of eradication is high, and thick scrub costs at least £10 per acre to cut. Allowing 15 lb of seed and 4 cwt of superphosphate at current rates, the total cost from scrub to grass is approximately £17 per acre.

However, thick scrub covers only a portion of most hill properties and, provided the finance is available, it can be controlled, or even eradicated, economically.

In undertaking development work on steep hill country, especially where pasture weeds are concerned, it is essential, above all, to plan and execute every phase of the work with care and vigour.

The availability of materials, machines, labour, and livestock, and the finance to purchase them, are essential ingredients of any development plan. No more work, therefore, should be undertaken than can be carried out to completion with the resources available. Any other approach to the problem ends in failure.

Acknowledgements

I gratefully acknowledge the help and interest of the officers of the Departments of Agriculture, Statistics, and Scientific and Industrial Research, and of fellow members of the staff of Massey Agricultural College.

Especially am I indebted to those farmers whose experience with manuka and tauhinu forms the basis of the control recommendations embodied in this paper.

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DISCUSSION

Q:: *Does Mr Small favour a split application of manure—that is, 2 cwt with the seed and 2 cwt later in the spring?*

A:: Yes. It is the clovers which must be encouraged and undoubtedly 4 cwt sown with the seed does produce a greater response than 2 cwt but it is better to split the application of it. Two hundredweight sown with the seed in the autumn is enough to establish the clovers but they make little growth until the spring when they grow and develop to maturity. If, therefore, 2 cwt is reserved and applied in the spring, just as growth begins, stronger and more vigorous clovers establish in the sward.

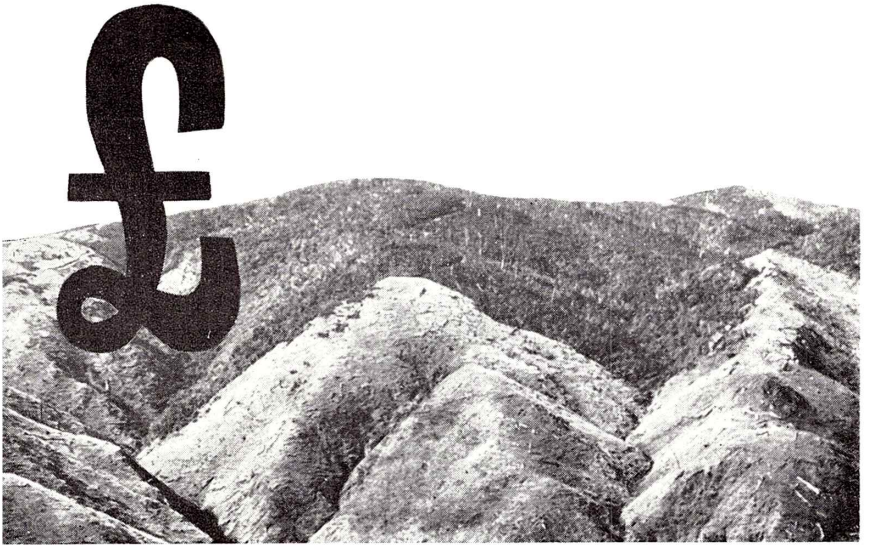
A further point is that, if heavy rains follow the topdressing of a clean burn on steep hill country, much of the fertilizer may be washed down into the gully. Splitting the application of fertilizers gives some insurance against a loss of this nature.

Q:: *Are there any figures on the viability of manuka seed?*

A:: The little information I have indicates that manuka remains viable for a very long time. A germination of from 10 to 20 per cent. has been obtained from seed kept dry for ten years. When one considers that a mature manuka bush may produce millions of seeds annually, this germination percentage could, in effect, be very high. It would seem that many seeds may remain viable in the soil for a long time so the sward should be kept thick to prevent the establishment of them.

Q:: *What has happened to the mealy bug which destroyed so much manuka a few years ago? In the Akitio district affected plants have recovered and seedlings appear to be immune from attack.*

J. M. Hoy:: In North Island areas, the insect responsible for killing manuka is, itself, being attacked by a parasitic fungus. The presence of this fungus has led to a marked decline in population levels of the mealy bug (*Eriococcus orariensis*) and subsequently to vigorous regrowth of manuka. The same situation occurs in the north-western portion of the South Island. Throughout the remainder of the South Island the insect continues to kill manuka. The area of effectiveness of the parasitic fungus appears to be governed by climatic factors, particularly temperature and rainfall.



A FINANCIAL INCENTIVE FOR LAND IMPROVEMENT

L. T. DANIELL*

THE TREMENDOUS POTENTIALITIES of the hill country pastures of New Zealand are still largely untapped. Where individual units of hill country have been well treated, the results have been phenomenal. But the back country man is short of finance and short of incentive. A dynamic financial project to re-develop hill country is needed to make possible a large-scale increase in the country's livestock population.

Today no undertaking in New Zealand except the meat and wool industry is capable of producing buoyant economic conditions. Coupled with dairying, its requirements cover the whole field of manufacture and transport. Dairying has had a bad knock and its former fund of £26 million is gone with the wind. What is the potential field of development for meat and wool?

In 1923 tests undertaken by the Department of Agriculture on the gumlands of the north showed that an initial 13 cwt of fertilizer per acre was required before pasture could be maintained by small annual topdressings. Similar tests in the Rotorua-Taupo

*"*Akoura*", *Masterton.*

area showed 9 cwt per acre to be the initial requirement in that locality.

Much of the hilly back country, once in fair pasture, now requires, say, 7 cwt of superphosphate before positive progress is shown. Assuming that 7 cwt per acre will cost £5 per acre to put on the hills, the problem immediately takes shape.

It is now suggested that money be made available to suitable hill country units at the rate of £5 per acre for the purchase and spreading of fertilizers, seeds and trace elements, this expenditure to be spread over a four-year term at the rate of 25s. per acre per annum. Thus a 1,000-acre property could plan the spending of £5,000 on fertilizer in four years.

Interest should be at the lowest possible rate, and repayment of the sum expended could commence in the fifth year and should be completed in the tenth year.

The Marginal Lands Board, consisting of a senior member from each of the four departments—Lands, Agriculture, Treasury and Soil Conservation—plus a farmer from both the North and the South Islands, has built up an excellent task force for its already large purpose. This Board could now administer a large-scale project to counter hill country deterioration and to rehabilitate hill country pastures.

The most serious problem of heavy taxation on loan repayment could be solved by giving the Board the right to strike a rate for repayment by properties which use the Board's loan moneys.

The Board would also require power to erect storage sheds, staff quarters and workshops on selected sites, to purchase and control land suitable for airstrips, and to develop them where necessary.

The Role of the Government

It is suggested that the Government could assist in the following spheres:

(1) Provide finance for the 10-year plan outlined above and thus assist to lift productivity of farms with a satisfactory potential.

(2) Approve and assist amalgamations in establishing economic units. New Zealand has fragmented too much of its farm land and the position must be faced.

(3) Give legislative authority to a cut in death duty and gift duty and to a return to the productive basis in the valuation of land. If death duties are not reduced, full use cannot yet be made of new opportunities.

(4) Make satisfactory arrangements for repayment of loans for

farm development. This should be the first incentive offered by the Crown.

(5) Re-institute reasonable depreciation on farm improvements and buildings.

An Improved Tax Structure

New Zealand farmers suffer under the most foolish tax structure in the world of agriculture. The Australian farmer is encouraged to spend capital sums in development of his farm, such sums being deducted from his income before income tax is assessed.

In Britain there is no gift duty, but in New Zealand it is used to prevent children receiving an interest by gift in the land their fathers have earned for them, and, in New Zealand, valuers—instead of valuing farm land on the basis of its production—are instructed to inflate values at death in a manner which should be ridiculed were it not destructive in its effects. The panic death duties of 1958 are still in existence, but the worst feature of all is the heavy taxation exacted from the enterprising farmer who wishes to repay a loan.

If a successful borrower now paying income tax at the rate of 10s. in the £1 wishes to repay £1,000 per annum, he must earn £2,000 and pay Inland Revenue £1,000 before he can repay his debt. If he is on 13s. 6d. in the £1 he must earn £3,000 and pay Inland Revenue more than £2,000 before repaying the £1,000.

These are the short and shabby facts concerning the treatment of this country's most enterprising settlers. When they repay loans they are compelled to pay not 20s. in the £1, but 40s. and 60s. in the £1. Thus those who raise a loan to pay death duties are on a treadmill for life.

On many hill country farms the outputs of both stock and wool are at the stage where revenue is insufficient for proper development, and deterioration is becoming progressively more rapid. Soon an expensive salvage programme will be a poor risk, for deflation stares everyone in the face.

New Zealand's cities are booming along with their multi-million pound expansion programmes. Huge new airports are planned, many-storeyed buildings, expensive motorways, and now more millions on the spendthrift wasteland of television. Undoubtedly manufacturing, housing and servicing industries have had a good year. But nothing has been done to stop the squeeze on farm incomes and farm profits.

Urban expansion can be paid for only with the receipts from rural production, and the outlook is grave. With butter prices far

below the payout figure of 32d., with the return for lamb at its lowest ebb since 1953, and the price of wool falling by 5½d. during this selling season, there must be some agonizing re-appraisals of the nation's till-money in the coming year.

A surprising feature of New Zealand farming is the smallness of the size of the holdings. Statistics show that 86 per cent. of the farm holdings are less than 640 acres in area, with an average of possibly 170 acres.

This means that over 30 million acres of hill pastures are sparsely populated by only 14 per cent. of the total number of farmers, though the effect of their primary production of meat and wool on the New Zealand economy is very high in relation to the population.

Some incentive to further increased efficiency must be allowed to farmers. If most of what they gain by hard work and capable thinking is taken from them year by year, and three pounds out of every five they have been able to keep, at death, the progress of efficiency is bound to be halted.

It should be kept in mind that what farmers can achieve in a year is not entirely decided by their own efforts. The season colours the picture with slump and flood and drought.

Now is the Hour

Today there are three alternatives available to a farmer on low fertility hill country who wishes a peaceful co-existence.

(1) Sell out if he can find a buyer.
(2) Spend nothing on maintenance and improvements and be prepared to walk off his farm in the foreseeable future.
(3) Obtain finance on a reasonable repayment basis.

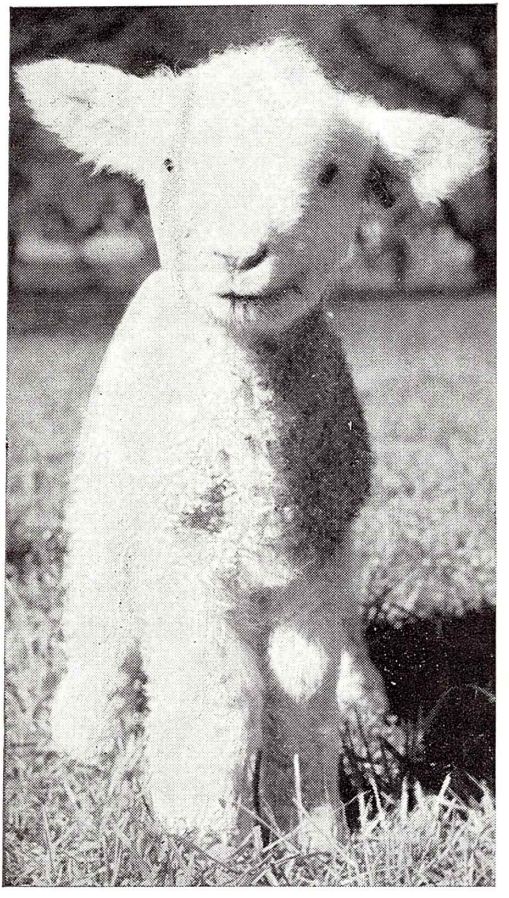
It is no use tying up hill country with taxation—it has to be farmed for its ultimate production. And it is no use spending little dribs of money. It is a costly job, and there are plenty of places to start and no place to stop.

The position is beyond compromise; farmers must grasp the nettle. If they do not spend money in order to hold the good pasture they already have, they must soon lose it.

The national development of low fertility hill country revolves around adequate finance, for there is everything there for high carrying capacity except fertilizer.

Huge areas are deteriorating without a word of protest; farmers cannot hold them with small amounts of money and an unwise tax structure. Hill country should have the constant benediction of fertilizer.

The penal taxation must be removed, money must be lent to the farmers to enable them to get on with the job. Now is the hour.



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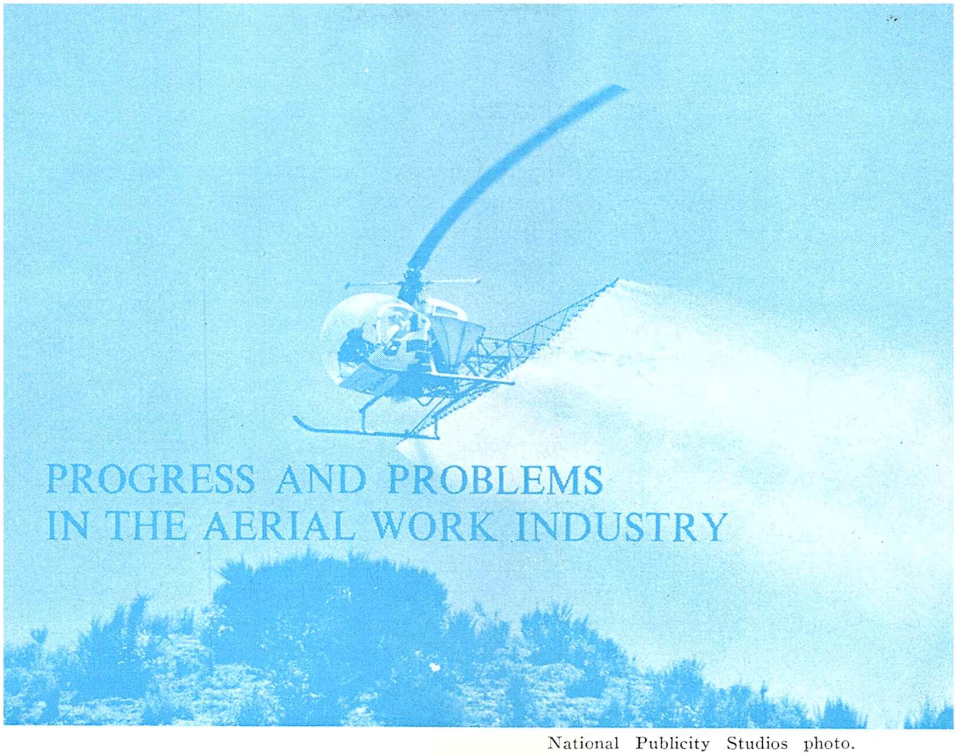

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PROGRESS AND PROBLEMS IN THE AERIAL WORK INDUSTRY

R. K. GARNHAM*

AN AUTHORITATIVE DEFINITION of the word "progress" is that it is an advance to something better or higher in development. In agricultural aviation, as in other fields of human endeavour, such advances cannot be achieved without overcoming numerous hurdles.

It is not widely appreciated outside the aviation industry why the relatively simple organization and procedures which are adequate in ground transport industries cannot be applied equally in aviation. In fact, among the few important factors common to them is the hard fact that operators must meet direct operating costs before they can look for any return on their investment.

Aircraft are more expensive than other transport equipment to buy, operate, maintain, and repair. There are many reasons for this, but they are all summed up in the objectives of the international and national legislation designed to protect the public, third parties on the ground, and the crews of aircraft, from the consequences of failure in the air of aircraft components, parts, and the materials from which they are made, or from faulty techniques used in flying and navigating the aircraft itself.

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In the air, the actual operation of an aircraft is governed by precise company or Government rules; and the personnel involved are the products of special, lengthy, and costly training and qualification.

In no other commercial industry is there such a complex of detailed regulation. It is essential for the protection of life and limb of innocent users in the air, third parties on the ground, and aircraft crews, but it is very expensive, as well as complex, and any comparison with other forms of transport has very limited validity. If a truck loaded with farm produce breaks down, say, because the operator has been cutting corners on his maintenance, the driver can light a cigarette, and wait for a tow. In the air a similar break-down produces results which are very different, for the pilot, the aircraft, its load, and possibly people on the ground. The precautions against this happening are multifarious, obligatory, exacting, continuous, often successful, always expensive, and ultimately the customer pays for them. It is hoped to show how these costs can be reduced, but no answer can be given to how they can be escaped.

Aviation is still largely an esoteric field, due mainly to the high degree of specialization which pervades it. Its very shop talk, threaded with allusion to the events, personalities, and special techniques around which it has grown and constantly evolves, can hold always the absorbed interest of those who "belong". But equally, its seeming gibberish brings exasperation or quick boredom to the uninitiated.

To those in the industry, it is equally as important as it is to the farmer that grass should grow. Its growth is the basis of our national and personal wealth. To maintain and improve that growth it is indisputably conceded that the agricultural aircraft has played a major part.

It is also generally conceded these days that to increase the production of the 20 million acres of hill country, aircraft must be used. To meet this demand the agricultural aviation industry has continually expanded its activities and services to the farmers. One might expect that the industry which plays such an important part in primary production might boast an imposing history of capital investment, a staff of many thousands, and an economy insulated against any possibility of its services being lost to the nation. This is not the case.

Civil Aviation Administration statistics indicate that in the past 12 months over 580,000 tons of fertilizer has been spread from the

air on to the hill country of New Zealand. To achieve this, operators, farmers, and general public alike owe an immeasurable debt to the 150 pilots who operate the 200 aircraft of the industry. These men have contributed to the national well-being of the country out of all proportion to their numbers. The tremendous effort of these 150 pilots is not appreciated and they remain unheralded and unsung.

It has been estimated that the agricultural aviation industry is directly responsible for earning approximately £50 million in overseas funds. Thus, this small group of men has helped the farmers to avert national bankruptcy or a grave decline in New Zealand's standard of living.

The growth and development of agricultural aviation over the past 12 years has shown a remarkable degree of progress. This progress, along with the problems associated, has been brought about by the drive and enthusiasm of a few who have now either taken executive positions in the industry or have left it. The useful operational life of an agricultural pilot has been estimated to be ten years and the industry is now facing a grave man-power problem. The shortage of trained agricultural pilots has become a major issue within the industry. It takes approximately two years to train an agricultural pilot to the stage where he becomes of some use to the industry. It is to be hoped that present studies being carried out by the entire aviation industry will indicate to Government and farmers' organizations that, unless some drastic measures are taken in the very near future, this problem will not be solved in time to avoid a serious set-back to agricultural aviation in this country. Should this set-back occur, it is obvious that all must suffer because of the reduced production which necessarily must follow.

The trend of operations in the past has shown a distinct seasonal demand for the services of the industry. It is appreciated that responsible farm management necessitates a defined cycle of top-dressing. However, today, with the demand for increased production, it could well mean that the farmer may have to modify and alter his present scheme of management in order to achieve the end result of increased returns. Farming today is not, and cannot afford to be, the haphazard administration and management of a piece of land with a productive capacity two or three times its actual output. A farmer must avail himself of every opportunity to maintain and improve his production at reasonable cost.

The seasonal trend established over the years requires the operator to maintain very expensive equipment to enable him to cope with the peak demand. As a result, unless the work can be spread over a longer period, and thereby avoid keeping the industry's fleet at the strength necessary to meet peak periods, it is inevitable that higher charges for aerial topdressing must come about. The remedy is entirely in the hands of the farmer. In the past such an increase has been avoided by exploring every possible way to improve the efficiency of ground equipment and aircraft. Many tens of thousands of pounds have been spent by some operators in technical development of their equipment. Farmers have indirectly paid for this, but, of necessity, the spending of this money by operators has reduced the capital available to improve further their service to the farmers in other ways.

During the last two years a partial improvement has been seen in the condition of some airstrips. It is vitally necessary that all farm airstrips should be maintained at a level that leaves as little as possible to chance in the life span of one of those so very valuable 150 pilots. Any factor that so endangers his, or anyone's life should be eliminated. If a pilot's life is lost through any lack of appreciation of his operational problems, the effects are not limited to the personal tragedy involved, but the operator and the farmer concerned are affected in material ways. The fatal accident rate in the industry is low in comparison with the number of flights made, but any relaxation of standards must inevitably lead to an increase in the number of accidents, bringing more rigorous departmental control, both being finally expressed in higher charges for agricultural aviation services.

The industry is more than anxious that costs to the farmer should be kept at a minimum economic level, and this can be achieved only by 100 per cent. co-operation between the farmer and the operator. Costs in the industry have risen substantially over the past few years. In 1950 a Tiger Moth could be purchased for as little as £200. Today, up to and beyond £10,000 must be paid for an efficient aircraft. The cost of maintenance has increased by 33½ per cent. Petrol, oil, aircraft parts, and materials have increased heavily in cost. In 1950, a pilot's wages were approximately £1,000 per annum. Some pilots today are reported to be receiving as much as £3,000 for a year's flying duties. Despite this, the industry has continued to offer a low cost service to the farmers. In 1950 the minimum price was £4 10s. 0d. per ton. Today it is approximately £2 15s. 0d. per ton. This industry must be unique

in that, in the face of rising costs, it has maintained or reduced the cost of its services to the farmers. It cannot be forecast how long this situation can continue to be maintained, and this distasteful subject will be left merely with the mundane observation that everyone must live.

Re-equipment of topdressing fleets through the generosity of the New Zealand Meat Producers Board was facilitated in 1954. Loan money at a low rate of interest was the only way in which the industry could have re-equipped to meet the colossal increase in the demand for its services. It is becoming apparent that further fleet capacity is now required in some areas. Loan moneys at high rates of interest have been available until lately from private sources, but this source of finance has largely dried up because of credit restrictions currently imposed on the country as a whole. The time would seem more than favourable for an examination of the requirements of the industry to ascertain if there is justification for re-activation of the Meat Board's aircraft loans scheme to meet the still-increasing demand for agricultural aviation services.

Research and development in any industry must run hand-in-hand with any progress made in it. The spasmodic attempts made in the past by various organizations, both Government and private enterprise, have produced little of value to the industry as a whole. Organized research is costly and time-consuming, and up till now it has been well outside the resources of the agricultural aviation industry itself to establish a full-scale research association of the kind operating in some other industries. It is hoped that ultimately the farming community and Government will realize that the results of organized research would not only keep the cost of aviation services to farmers down to practical levels, but would widen the scope and efficiency of agricultural aviation. One avenue of research that could well mean millions of pounds in increased production has from time to time been very forcibly presented by L. T. Daniell, that well-known farming personality. He has proposed a plan for the eradication of manuka from potentially productive hill country. An economic scheme of eradication could create an overall increase in production of 50 per cent. subject to finance being available for it.

Every community always has within it the pessimist who thinks of nothing but the recession, which is to him always just around the corner. This pessimism is contagious, as everyone will well remember from the experience of at least one politically-inspired recession of recent times. The effect on agricultural aviation was

quite obvious. Some farmers decided to reduce their fertilizer requirements drastically for a season, and such a reduction led to an economic crisis in the industry. With its expensive equipment, and very slender reserves, it was not geared to meet that kind of set-back.

It was as a result of this development in the year 1958/1959 that the then Minister of Agriculture set up a Committee of Inquiry to ascertain among other things the cause and extent of the difficulties that were stated to beset the aerial topdressing industry, and to investigate any factors affecting or likely to affect its economic stability. The inaugural meeting of this committee was held some 18 months after the aforementioned crisis. It was appreciated by the committee that by this time the industry had of its own initiative and with the improvement of overseas prices gone a long way to regaining an even keel. During the course of its discussions, the committee received from Mr Daniell, a member of the committee, a draft of the proposal mentioned above. The Aerial Work Division of the Aviation Industry Association considered this plan and approved it, with the reservation that the necessary planning and organization to implement it should be carried out then in order that the plan could quickly come into operation when a serious economic set-back occurred.

As a result of the recession during 1959, some operators were hit harder than others. This depended largely on the locality of their operations and the then financial stability of their companies. Some of these companies did, in fact, subsequently disappear or were absorbed by larger ones. The term "consolidation" has been heard, as inevitably it would be heard, throughout the industry during recent years. This so-called consolidation has been brought about in various ways. The merging of financial interests, the outright purchase of assets, or the well-known method of "take-over" have all been used. Consolidation, carried to reasonable limits, creates stronger operating units, from which both farmers and operators could expect to benefit in various ways. In the past five years, nearly twenty-five topdressing companies have been taken over. This may be part of the normal evolution of any new industry, and, if so, may work itself out. In that event, there is no need for concern. But farmers could well consider whether it would be to their advantage if the process continued to the point at which they found that they no longer had reasonable scope for selection in the letting of aerial topdressing contracts.

Sir Bruce Levy, in a paper published in *Sheepfarming Annual,* 1959 (p. 119) says:

> "Farming today is not a question of a farmer's own pair of hands, however willing they may be. It is a question of using and exploiting to full advantage the canned labour of many individual pairs of hands not resident on the farm.
> "Today aircraft have put an entirely new complexion on the problem of hill country topdressing, and continued topdressing is necessary if the valuable service built up over the years by pilots of the aerial topdressing companies is not to be lost."

The farmer is charged with responsibility to increase production, and events which seem imminent in the European scene are likely to heavily under-score the vital nature of this duty. Rest assured that the aviation industry will meet its obligations to assist the farmer in discharging it. The whole concept of agricultural aviation may have to be revised to meet any future challenge. It may mean that bigger and more efficient aircraft will be required. It may mean that flying techniques will need revising, and still more proficient pilots trained. There have been crises in the past and there will be more in the future, but preparation and planning can go a long way in lessening their impact initially on the aviation industry and consequently on the farming community. Despite temporary set-backs, there should be no doubts entertained about the future of New Zealand's primary industry and the brightness of this country's future. With a temperate climate, and advanced knowledge of grassland farming, combined with the inherent ability of the farming community, how can this country's primary industry fail to be one of the main suppliers of foodstuffs and clothing to the ever-increasing population of the world? With aircraft, production can be stepped up, and aircraft will soon be able to carry agricultural products to the world's market places. The consumers wait in their millions. The only barrier between the producers and them is the agricultural cost structure. Mention has been made of a few things which in the aviation segment of agricultural work, can be done to reduce costs. An effort should be made to spread work over a longer period of the year; airstrips should be kept in decent condition; stock should be kept away during operations; if a topdressing operator is giving good service, he should not be changed merely for a small saving in price—the

devil you know is said to be better than the devil you don't know, and the ghosts of 25 departed topdressing companies perhaps prove that it may be so in agricultural aviation.

The resources and equipment of the New Zealand agricultural aviation industry can be relied upon to play an extremely important part in preserving economic stability in this country and thereby ensuring that there will be no deterioration in standards of living.

DISCUSSION

Q:: *Do any plans and schemes exist to subsidize the training of young pilots such as those available for training shearers or schoolteachers?*

A:: A study group has been formed to examine the shortage of pilots in the aviation industry. This study group should complete its investigation early in August and a report will then be forwarded to the Minister of Civil Aviation. The report should cover such problems as training, terms and conditions of employment, etc.

Q:: *What are the peak seasonal periods for aerial work and how may farmers avoid this, especially having regard to the impossible conditions of many farm airstrips in winter?*

A:: It appears that the peak seasonal periods are between the months of September to November and February to May. To what extent farmers avoid these periods I have no information except that demand on the existing aerial work services may influence some farmers to apply fertilizer by air in months other than those mentioned before.

Q:: *Would the aerial topdressing firms give farmers concessions for out-of-season work?*

A:: In the Auckland and Waikato areas operators have given farmers concessions for out-of-season work. In other areas it is felt that, if the fertilizer works, railways and road transport operators give a concession, the aerial work industry would then also consider a concession for out-of-season work.

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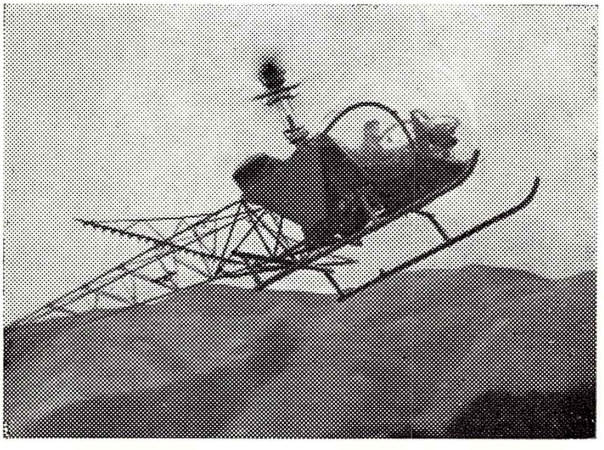

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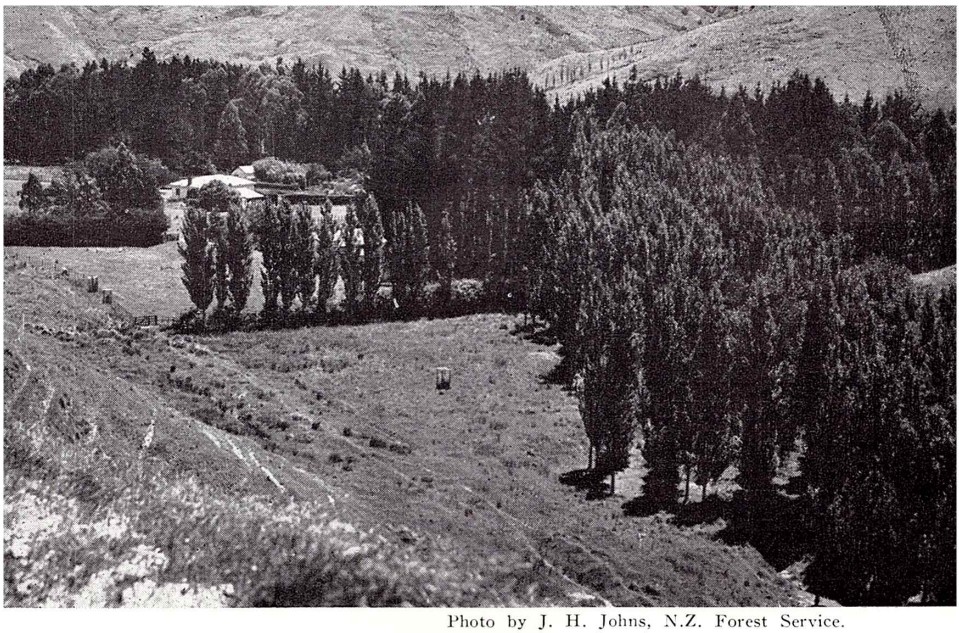


Photo by J. H. Johns, N.Z. Forest Service.

THE POPLAR AS A TIMBER TREE IN ASSOCIATION WITH GRASSLAND FARMING

C. W. S. VAN KRAAYENOORD*

POPLARS were among the first exotic trees brought into New Zealand by the early settlers and the well-known Lombardy poplar must have been planted as early as 1840. Other types of poplar followed and it is recorded that the first Black poplars on the Canterbury Plains were planted by the Dean brothers at Riccarton in 1851. Their value for shelter and ornamental planting was soon recognized and they were spread rapidly all over the country.

Poplars are now such a common sight that they feature in many a New Zealand colour photo, particularly in autumn pictures of such scenic attractions as Lake Wanaka or Wakatipu. These pictures may have confused the Food and Agriculture Organization of the United Nations (FAO) for, on its recent world map showing the various countries where poplars are of particular importance as a timber tree, the South Island was included among the principal areas of poplar cultivation!

However premature the inclusion of New Zealand on this map may appear now, the writer firmly believes that in the near future poplars will be recognized as a timber species which could play an important role in farm forestry in New Zealand.

*Soil Conservation Service, Department of Agriculture, Palmerston North.

The following few examples from other countries where poplars are already of great importance to the timber, pulp, and paper industry are of interest.

In France nearly 250,000 acres and in Italy 85,000 acres are planted in poplar, mainly in conjunction with agriculture. In fact, in these countries, poplar is a tree belonging more to agriculture than to forestry. In Holland, where poplars are mostly planted along roadsides, canals, and boundary fences, some 10,000 miles are planted in single rows. They cater for 20 per cent. of the Dutch timber production. In England where poplar culture was formerly of minor importance, the growing of poplars is now encouraged by a grant of £17 per acre or 2s. per tree for line planting. In the United States of America and Canada, countries which cannot be regarded as being short of timber, poplars are planted on an increasing scale. In the Southern Hemisphere also, where poplars are not a native species, large areas planted in poplars can be found in the Argentine (200,000 acres), Uruguay, and South Africa. Only last year it was reported that large poplar plantations will be established in Tasmania.

There is now a world-wide interest in the use of hybrid poplars for timber production. The importance of the tree was recognized by FAO which, in addition to an International Eucalypt Commission, has also established an International Poplar Commission to promote international co-operation in the study of all scientific, technical, and economic questions relating to poplar cultivation.

There are two reasons why populars occupy such an important place in the timber production of these countries and are such favourite trees with farmers and landholders.

First, its very rapid rate of growth makes it possible to obtain a financial return during the lifetime of the planter. It is one of the fastest-growing broad-leaved trees with an economic rotation of 30 to 40 years but, even in 25 years, will give high yields.

The second reason is its ability to grow well outside a forest environment. Poplars have not necessarily to be grown in plantation form but can be planted either in small groups in single rows along roads, streams, and fencelines or as isolated specimens—thus, on land which has another use besides timber growing. In fact, under these conditions they will grow faster than in plantations.

Poplars can be grown profitably in association with grassland farming, provided the correct types are used and adequately spaced.

While they undoubtedly compete to some extent with pasture for nutrients, the improvements in microclimatic conditions are

compensating features. As well as providing shade and shelter for stock, they will reduce wind velocities with a consequent reduction of evaporation and transpiration and an increase in dew formation.

For maximum production, they require moist, fertile soils, long, warm summers, and high light intensities. These requirements can be met in New Zealand as the country has the right soil types and climatic conditions. However, although the first poplars were introduced into New Zealand over a hundred years ago, they have been neglected here as a timber species.

Since 1945, however, with the beginning of the soil conservation movement in New Zealand, poplars have received more and more attention as a species suitable for soil conservation in gully control, hill side stabilization, and riverbank protection. At present some 400,000 poplars are planted annually with Soil Conservation subsidies. This number is rapidly increasing and it is expected that many of these trees will eventually produce useful timber.

Timber Quality and Use

The qualities of poplar timber are not generally realized. In New Zealand, poplar timber has been judged by the most common species, the Lombardy poplar. This species, however, yields an inferior timber and cannot be regarded as a timber poplar.

Poplar timber has many special uses because of its white colour, lack of smell and resins, workability, softness, light weight, relatively high strength in proportion to its weight, and its resistance to splintering. It can be easily stained or varnished and it takes paint well.

Pulp

All poplar species are easily pulped. Poplar pulp has a high cellulose content and short fibre and is very suitable in the production of better quality papers. The well known American journal *Life* is printed on paper containing 35 per cent. poplar pulp. A representative from one of the local pulp and paper mills has stated that they are engaged in a poplar planting programme and will in the near future accept poplar timber for pulping.

Veneer

The most profitable venture in poplar culture is the production of peeler logs for veneer. Veneer is used for plywood, matches, small size boxes, chip baskets, etc. Poplar has been peeled for

veneer in New Zealand and the veneer industry will at present take logs with a minimum girth of 4 ft 6 in. and length of $6\frac{1}{2}$ to $8\frac{1}{2}$ ft. An advantage of poplar for veneer is that it can be peeled without prior steaming.

Regular and careful pruning is essential for the production of quality peeler logs free from knots.

SAWLOGS

Poplar is a useful milling timber. It can be used for interior carpentry (it holds nails and screws well), box timber (lack of smell), truck and tray bottoms, sheep crates, and bridge decking (tough and does not splinter).

On the farm it can be used in gates, yards, and battens (all treated). The use of treated poplar for fence posts is at present under investigation.

Poplar has many other minor uses—for example, drawing boards, kitchen utensils, artificial limbs, trays, and for turnery and woodwool.

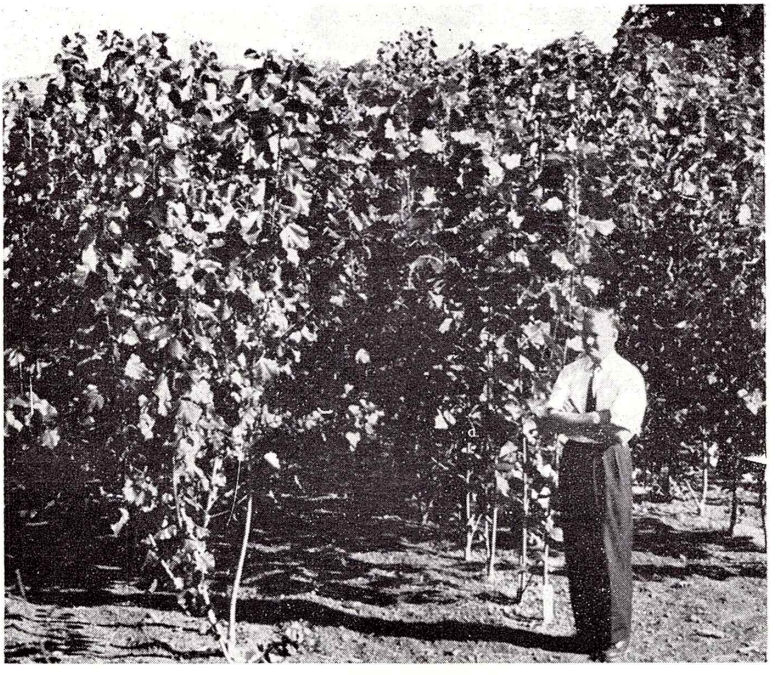
With the dwindling supply of native white pine or kahikatea, poplar timber is well suited to take its place in the future. One of the freezing works is at present experimenting with poplar timber in the manufacture of casks for tallow, hides, etc.

Yield and Financial Return

Comparison with overseas figures suggests that in New Zealand higher yields per acre can be expected than in Western Europe. The growth rate appears to be similar to that in Italy where poplars are in their optimum stage.

The writer has measured many trees with a diameter growth of 1 to $1\frac{1}{2}$ in. per year. A 15-year-old stand on good soil near Hastings has an estimated volume of 4,500 cu. ft per acre, and, with the most productive period still to come in the next 10 years, should reach 7,000 cu. ft at age 25. In single-row planting on first-class sites, volumes of 60 to 70 cu. ft per tree can be expected in 25 years. When planted in combination with pasture at a very wide spacing of, say, 15 trees per acre, it should be possible to obtain a total yield of 1,000 cu. ft per acre under New Zealand conditions.

Because of their rapid growth and high productivity, hybrid poplars are one of the most profitable trees which can be grown on farms in European countries. Prices obtained for poplar saw-



Poplar cuttings 7 months after planting are approximately 12 ft high.

logs are regularly quoted as high as 5s. per cu. ft, or more than double the price of similar quality pine timber.

Dutch figures based on all costs over a 25-year rotation (including a 4 per cent. interest on invested capital) show a net profit of £6 to £8 per tree or with 100 trees per acre £600 to £800 per acre, or £24 to £32 per acre per year.

In Germany, the normal yield of widely-spaced poplars on alluvial soils is 285 cu. ft per acre per year—a gross value of £35 per acre per year.

When grown in a single line along fences at 12 ft spacing, this works out at a return of approximately £40 per chain or £3,200 per mile in 25 years. This is not a bad return considering that with row planting farmers still have their paddocks left to fatten some sheep as a sideline.

In Italy the value of the additional profits by planting poplars in combination with agriculture is well recognized. In the Caudina Valley, a region of small land ownerships near Naples, the poplar is used in a custom that has been handed down from generation to

generation: at the birth of a daughter it is customary for the father to plant about 100 poplar trees; when the daughter marries these trees are her dowry.

If this custom were adopted by New Zealand farmers they could give their daughter at 25 years a dowry of £800. In case this is considered insufficient, it is suggested that 200 poplars might be planted.

These figures, quoted from overseas experience, may not be considered applicable to New Zealand conditions.

The veneer industry, however, assures the writer that they will offer for quality peeler logs delivered at the mill 80s. per 100 H/D (log) measure* or 7s. 6d. per cubic foot. It should be possible to obtain 3 peeler logs of 15 cu. ft each out of a 25-year-old tree. This is a gross return of £16 10s. 0d. per tree.

A firm in Hastings at present pays 100s. per 100 bd. ft for clean 7 in. x 1 in. to 12 in. x 1 in. boards. This means a gross return of £13 10s. 0d. from a 25-year-old tree.

The demand will no doubt increase when more poplar timber becomes available and its qualities are better appreciated.

Selection and Management

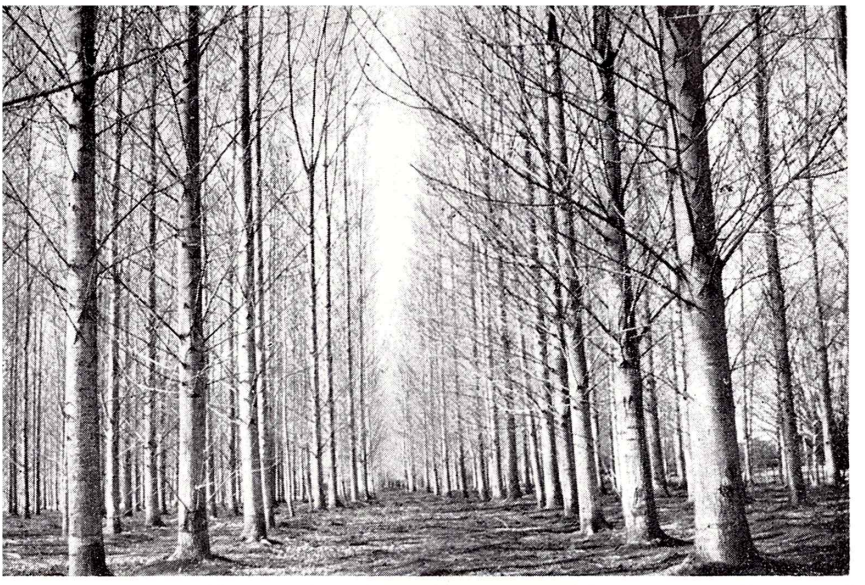
To make farm forestry a worthwhile venture, high quality timber must be produced and this is not possible without proper management. This applies to all species but particularly so to poplars.

The growing of poplars for timber does not need any special skill but, particularly in their early stages of growth, they do require a certain amount of care and attention. The poplar is not the species for the farmer who expects casually planted and subsequently neglected poplars to grow into valuable timber trees.

Some of the technical aspects of poplar culture should give a better understanding of their particular requirements.

The most profitable poplars to plant are the Black hybrid poplars. Botanically, poplars can be classed into three groups: the Silver poplars, the Balsam poplars, and the Black poplars.

*The Haakon Dahl or log measure is used mainly in the North Island and is based on the formula $(G/4)^2 \times L \times 12$, where $G =$ centre girth in feet and $L =$ length in feet. The volume of a log expressed in H/D is 9·4248 times the true cubic volume and approximately 1½ times the sawn board output. [Ed.]



A 14-year-old plantation of Populus robusta *with an average diameter of 13 in. and height of 65 ft. The trees are well spaced but pruning has been neglected, reducing the timber value considerably.*

Several species of each group can be found in New Zealand but nearly all the timber-producing poplars belong to the Black poplars or, more precisely, the Black poplar hybrids.

Poplars are dioecious trees, which means that the male and female flowers are borne on separate trees. They hybridize quite freely and many hybrids between the various species have originated naturally. It was found that several of these hybrid poplars grew much more vigorously than the original parents. When this was realized, many more hybrids were produced artificially in the search for still better and faster growing types. Moreover, as there are some serious poplar diseases in Europe, this breeding work was also directed towards the selection of disease-resistant hybrids. In several countries there are now special poplar research stations concentrating on breeding and selection work.

After selection, a promising poplar hybrid is further propagated vegetatively by cuttings. All future trees will therefore have inherited the same potential characters as the original parent tree; they have the same growth habit and rate of growth, the same sex, and come into leaf at the same time. They all belong to what is called the same *clone*.

Varietal Control

As a result of this breeding work, a bewildering number of hybrids exist overseas and in New Zealand already over 60 different clones have been recorded. Many of these hybrids are very similar

in appearance but differ with regard to site conditions, rate of growth, timber quality and disease resistance. Great care should be taken in selecting only the best types available for each purpose or locality.

The identification of the various poplar hybrids is very difficult and there is much confusion in existing plantations and nurseries.

To clear up the existing confusion, the Soil Conservation Service of the Department of Agriculture has established a central nursery at Palmerston North for the collection and identification of poplars available in New Zealand, for the introduction and propagation of promising disease-resistant varieties from overseas poplar research stations, and for the selection and distribution of material certified as being true to name, to catchment boards and commercial nurseries.

Already several new faster growing and more productive poplar hybrids have become available in the last five years and this number will no doubt increase with further selection.

It is necessary to stress the importance of varietal control, so that only types of known origin which are resistant to disease and capable of producing marketable timber are being planted.

Soil Requirements

Poplars require moist, fertile soils for maximum production. Loamy, alluvial soil types are preferred but poplars will grow well on other soils as long as sufficient moisture is available. They can stand a high water-table, but dislike continuously water-logged conditions. Droughty soils, acid peat soils, and undrained swamps are unsuitable.

Establishment

On areas with sufficient moisture during the summer, poplars can be established from 8 to 10 ft long sets or poles, planted at least 2 ft deep, but in general, one-year-old rooted trees are preferred as they grow faster and are easier to establish. The non-availability of sufficient good quality poles will also be a limiting factor in pole planting.

The best way to obtain sufficient trees is to establish a small nursery. Poplars can be easily propagated from cuttings about $\frac{1}{2}$ in. in diameter and 9 in. to 12 in. long, prepared from straight one-year-old wood. Cuttings should be planted in well-worked-up soil at a spacing of 9 in. to 12 in. in the row, and 18 in. to 24 in. between the rows. Planted up to nearly their full length during August and pruned to a single shoot in November, they will, with

some cultivation, have reached a height of at least 6 ft by the end of April and will be ready for planting out that winter. They should be planted out in pits approximately 18 in. deep. This deep planting does not affect the young trees and provides extra stability in exposed positions.

For the first two years after planting, grass and weed competition should be kept to a minimum in a 3 ft wide circle around each tree. This is the most important factor for successful establishment and vigorous growth. Young poplars are very susceptible to the inhibiting effect of grass and weeds which cause lack of nitrogen. Vegetation can be eliminated by cultivation, heavy mulching with grass or old hay, or by spraying with dalapon. A topdressing with 4 to 8 oz of sulphate of ammonia will also stimulate early height growth of the young trees.

As mentioned, all trees belonging to the same clone have the same rate of growth. For this reason poplars need a wider spacing than most other tree species. This is an essential difference between poplars and other trees which are raised from seed and which form a collection of different individuals.

In plantations, poplars should be planted 15 to 20 ft apart, while in row planting the spacing should not be closer than 12 ft. A closer spacing is usually not desirable as the intolerance to light and root competition will necessitate a heavy thinning at an early age. Except in close proximity to the pulp and paper mills, there does not appear to be a market for these thinnings at present.

Pruning the side branches should begin at an early age. With vigorous growing trees, pruning should be done regularly every two, or at the most every three years, taking only some of the lower branches each time. Delayed pruning will reduce timber quality. Sudden heavy pruning should also be avoided as it will induce a heavy crop of epicormic or water shoots. Gradual pruning will prevent this. Poplars pruned to 20 to 25 ft in height will not only yield a good quality timber free of knots, but in line planting high pruning will also reduce the amount of shade so that grass will grow right up to the trees. Moreover, stock will not concentrate under the trees as they follow the shade further out from the trees.

Species Selection

For farm planting, preferably male or shy-seeding female clones with a narrow crown should be selected.

In single-row planting, narrow-crowned poplars will cast less shade and form no overhanging branches. In exposed positions they also keep their upright form better than the heavier, wider crown varieties which tend to lean away from the prevailing winds.

The male clones are preferred because the catkins from some of the female poplars release large quantities of a "cottonwool"-like seed in December which will cover the pasture for some time. Although no ill-effects have been reported in New Zealand, it is stated in Europe that this "cottonwool" can be troublesome to stock. It may also be a nuisance near buildings or on roads.

The most promising poplar hybrids for timber production on farms are *P. robusta* and its new selection *P. robusta "PH"; P. eugenie "PU"; P. laevigata* and the Italian hybrids I.30, I.78, and I.455.

They are all Black poplar hybrids with straight stems and rather narrow crowns suitable for line planting. The fastest growing Italian hybrid, I.214, develops a wider crown and is not as straight as the other Italian hybrids. It appears more suitable for planting in plantations.

With the exception of *P. robusta,* all these clones have been introduced during the past 10 years. New Zealand experience is still rather limited but performance in the early stages compares favourably with that overseas where they have been tested in many countries. A number of other hybrid poplars introduced recently appear very promising but they need further trial before they can be recommended for general use.

Conclusion

In this paper an endeavour has been made to give a general outline of poplars as a potential timber species for New Zealand, together with some of the technical aspects of poplar cultivation.

Poplar planting is already carried out for soil conservation on farms and will increase considerably in the future. Provided the improved timber varieties are used and properly managed, these trees will yield profitable timber besides giving stabilization.

There is considerable scope for the expansion of poplar cultivation on farm-land not affected by erosion, on the better lowland soil types, and also on the many moist hill country valleys, thus ensuring maximum land utilization.

Poplars are better adapted to sites with a higher water-table than conifers and they do not necessarily have to be grown in planta-

tions for quality timber production but are well suited for planting in small groups or single rows in combination with agriculture.

On these areas the rapid growth of the newer hybrid poplars and their high production of quality timber on relatively short rotations, will provide an additional financial reward to that derived from normal farming.

DISCUSSION

Q:: *How do you transplant trees from the nursery when they have reached a height of 7 to 8 ft, and will the roots left grow again?*
A:: Trees are lifted using a strong sharp spade. Roots on trees should be about 6 in. long. All roots should be clean cut. Never pull trees as roots are easily torn. Some roots left in the ground will send up suckers.

Q:: *When this occurs is it better to kill off the suckers with an all-purpose spray or shift the nursery?*
A:: Neither course is necessary, as young green suckers can be easily pulled out by hand or controlled by regular hoeing.

Q:: *What size do the trees have to be when planted so that they will be unaffected by cattle?*
A:: Trees have to be protected from cattle for several years.

Q:: *Is there any poplar variety resistant to opossums?*
A:: Balsam poplars (*P. generosa, P. yunnanensis*) appear less palatable than Black poplars. There is no guarantee that in future opossums will not acquire a taste for Balsam poplars too. Opossum control is the only answer.
A MEMBER:: In our small nursery it has been found that Black poplars are resistant to opossums but Lombardy poplars are readily eaten.
A:: Lombardy poplar is most severely attacked but other Black poplars such as *P. robusta* and *P. laevigata* have been attacked in other areas. You have been lucky so far.

Q:: *Would the underplanting of bamboo affect a single row of poplars trimmed to improve their timber-bearing capacity?*
A:: No, but to provide effective shelter the height of pruning is determined by the growth rate of the bamboo.

Q:: *What is the best way of planting poplars where they are not protected from cattle?*
A:: Poplars should be protected from cattle. Where only small numbers are planted, individual protection is possible and will pay for itself by the timber produced. Trials with stock repellents are in progress but results are not encouraging.

Q:: *How far do the roots travel?*
A:: Poplars have a wide-spreading root system. Roots can be expected 1 chain away from the trees. To prevent roots from blocking tile drains, a mole plough can be used to cut the roots about half a chain away from the trees.

Q:: *Does poplar timber require preserving for general building use?*
A:: Yes.

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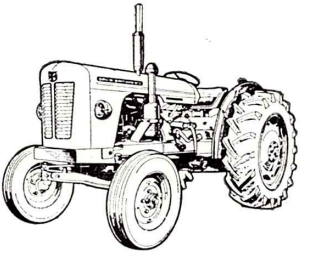

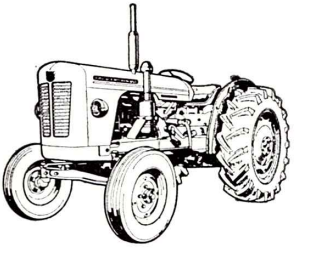

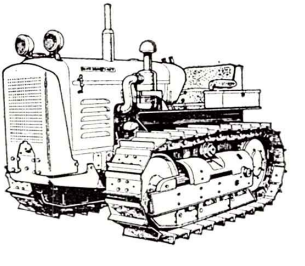

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FARM WOODLOT MANAGEMENT

D. S. JACKSON*

PROFIT is the primary object of management, and the subject of relative profit under forest or pastoral production as alternative forms of land management must ultimately concern forester and farmer alike. The matter is a very involved one, however, and is at present obscured by a mass of impressions and data which are all too frequently due to the lack of any clear objectives in farm planting and to subsequent haphazard management of the plantations concerned. It is for these reasons that this paper waives the larger issue and elects instead to attempt to clarify objectives and the necessary commitments in farm-woodlot management. In other words, an endeavour will be made to look at farm forestry from the farmers' point of view, as an activity essentially complementary to his pastoral and agricultural production.

*New Zealand Forest Service, Napier.

There are four main reasons for farm planting:

(1) To meet the farmer's need for timber in all its forms.

(2) For homestead and general farm shelter.

(3) For soil and water conservation.

(4) For aesthetic reasons.

These four objectives are all to some extent interdependent; but the subject of this paper concerns only the first of them, namely, management for timber production.

There is no reason why all farm requirements of timber should not be grown on the property—and the more remote the farm, the more economic it becomes to be self-supporting in this regard. Timber is a bulky product to transport, and the unconverted log is even more wasteful in freight charges. As haulage distance increases it becomes progressively more unfavourable, in terms of stumpage paid by the miller, to ship logs out to a distant sawmill. Conversely, however, the importation of timber products becomes increasingly costly, and greater economies can be achieved by self-sufficiency. By contrast, the farmer who is situated in close proximity to processing plant and to centres of consumption is in a favourable position to command maximum stumpages for all classes of raw forest produce, and can purchase his requirements of processed timber without paying a premium for transport.

To these factors must be added further differentials for hiring or importing heavy equipment for logging and extraction, and the relative availability of a casual labour pool, or dependence on seasonally-available permanent employees.

Thus, it is obvious that the formulation of management objectives must give very different emphasis to the various categories of farm woodlot production. In brief, these distinctions may be summarized in the following principles:

(1) The nearer the farm to sawmill and centres of consumption, the more profitable does it become to manage woodlots for stumpage, by the production of sawlogs to meet demand for general-purpose softwood timbers or of cordwood for pulping.

(2) With increasing remoteness from markets for stumpage, farm forest management should aim at local self-sufficiency in all timber products from firewood, battens and posts, to farming and hardwood construction. In so far as sawlogs may be produced for export, these should be of maximum piece-size and

maximum quality—that is, selective silvicultural attention is essential, in order ultimately to command the greatest stumpage per unit of log-volume.

Unfortunately, all too many farms in remote areas are faced at present with the very antithesis of this—*i.e.*, small isolated lots of untended knotty pine which are more nearly a liability than an asset.

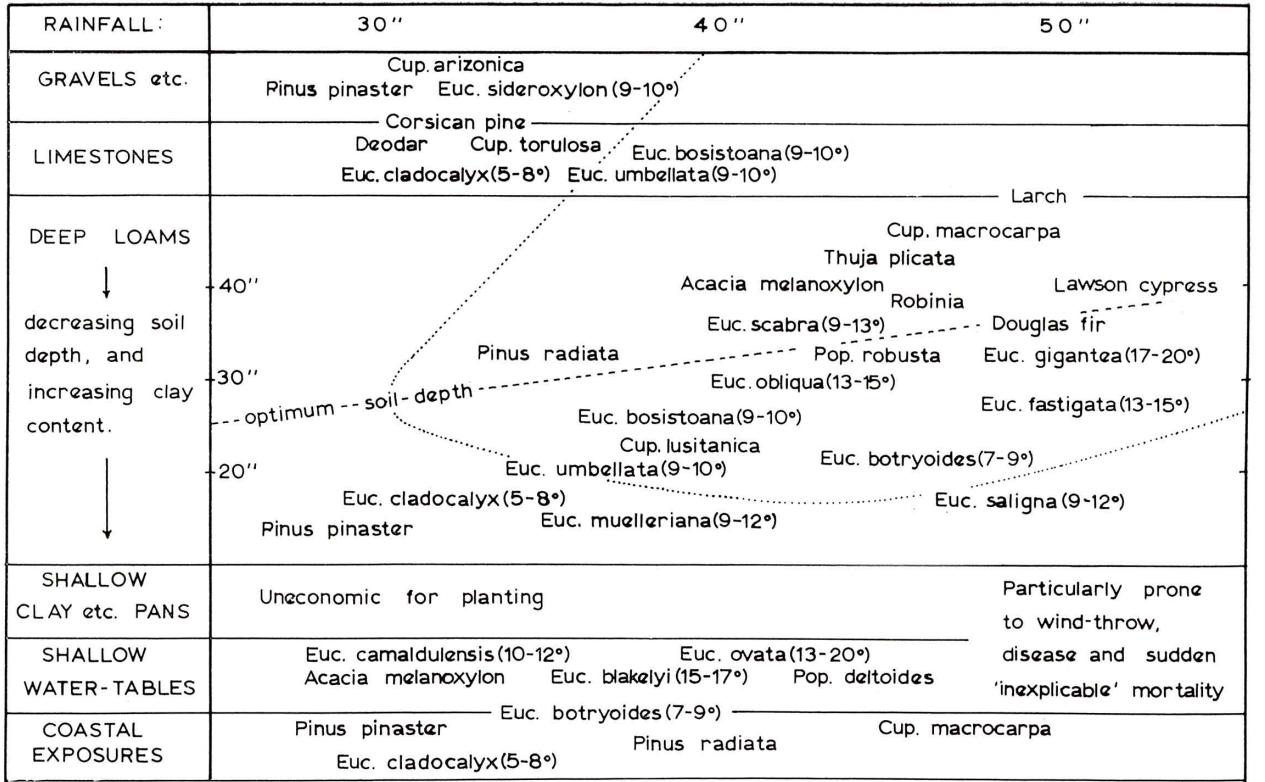
Establishment and Choice of Species

Considerations of market value and local requirements, of intrinsic timber properties, relative durability, etc., cannot be divorced from the sites available on the farm and the local pattern of climate—since these determine the species which may successfully be grown.

Figure 1 represents diagrammatically the range of conditions under which the principal species suitable for farm forest production may be grown in Hawke's Bay. Within this district the principal environmental factors not amenable to human control are the rainfall and the soil. The range of tolerance for each species approximates the shape of the figure for radiata pine (*Pinus radiata*), but shifted in its location to centre on the species concerned. Outside this range, and particularly under conditions corresponding with those to left of the apex, the species will become progressively less thrifty, less productive and more prone to disease. Optimum soil-depth increases with rainfall, and as these both increase so does the productivity of the site in terms of timber volume also increase. The average yields obtainable from many of these species at any age can be read from appropriate Forest Service tables.

For a number of species the degree of resistance to frost-damage may also be a limiting factor in Hawke's Bay, particularly during the phase of plantation-establishment. Since frost-intensity is greatly dependent upon microclimate, as determined by both site and local shelter, it is most practicable to express this factor as degrees of frost-tolerance by the species concerned. This is shown in parenthesis where appropriate.

From study of Fig. 1 the farmer should be able to determine what species are most suited to the environment of the site he has in mind. From among the species he may then select those which are likely to fulfil most closely his objectives and needs. It is at once apparent that the farmer who is situated in a relatively frost-free region (*e.g.*, near the coast) having an annual rainfall of 50 in.



SITE-ALLOCATION OF SPECIES FOR FARM FOREST MANAGEMENT IN HAWKES BAY DISTRICT

Showing annual rainfall regime and soil-requirements. Degrees of frost-tolerance for tender species in parenthesis

Fig. 1.

and loamy soils 30 in. or more in depth, is in the fortunate position of being able to grow nearly every species listed. Conversely, for sites on limestone in a 30 in. rainfall zone, there are only three or four reliable species. However, Fig. 1 makes no pretence at being exhaustive, and there are numerous species which are still in the experimental stage and are promising—*e.g.*, the boxes.

Tending

Anticipating the planting and tending commitments is essential to rational woodlot management, and to do this it is essential to bear in mind the different requirements of coniferous and broad-leaved species, and the stages of development at which certain operations become due if quality of product is to be attained.

Generally speaking, it may be said that for each acre of coniferous plantation somewhere between 1 and 2 man-days will be required for initial establishment. Between 5 and 12 years later, depending on species and site, a further 2 man-days per acre will be required for pruning 200 to 300 trees to a height of 6 or 7 ft. Three to five years after this, a like commitment is necessary for high pruning.

Operational flexibility is desirable in this as in any form of management, and for integration with the farming calendar it is most essential. If tending (and its ultimate rewards) are not to go quite by the board, these demands on labour must be anticipated; and the problem will become progressively more critical as the scale of operations increases. It may be ameliorated by staggering plantings over two or three decades, by using a range of species which develop at different rates, or by balancing coniferous species with others, such as the eucalypts, which do not require pruning.

However, one is here again faced with the different circumstances which confront the management of units relatively close to centres of population and those which are more remote. In the former instance, casual labour on a contract basis is frequently available for pruning, and royalties for posts make thinning an attractive proposition. Thus silviculture can be practised both more intensively and on a larger scale. Conversely, on the more remote unit, with only sporadic seasonal labour available, the tending schedule must be as flexible as possible. This can best be achieved by concentrating pruning only on the finest and most vigorous selected stems, and precluding subsequent damage to these by immediate removal of coarse malformed dominants which may com-

pete with them. Once these trees have been selected and treated, the residue of the stand can be thinned and utilized whenever labour is available and as various classes of produce are needed about the farm. The latter operations can be left to relatively unskilled men, but the initial marking of select trees and undesirable competitors should only be undertaken by the woodlot manager himself.

Marketing and Utilization

The initial questions may be repeated: "What are the objectives of the owner?" and "How far can these be met, having regard to the factors already discussed?"

At present the species most readily accepted by the market because of their familiarity and past performance, are radiata pine and Douglas fir, or "Oregon pine" (*Pseudotsuga taxifolia*). Within the range of environmental conditions appropriate to either of these, they are also the most productive in terms of timber volume —the former on shorter rotations (up to 40 years) and the latter on longer rotations (over 50 years). Hence, where the farm is near to market and sawmill, these species should constitute a substantial proportion of the woodlot. The readiness with which radiata pine thinnings can be treated with preservative and their profitability as posts, etc., reinforce this conclusion; although for Douglas fir a factor to be considered is that thinnings require a pressure plant for satisfactory treatment. Other species which could command a good market as quality saw logs would be macrocarpa (*Cupressus macrocarpa*), larch (*Larix* spp.), certain of the poplars, and *Eucalyptus botryoides*.

Nor should the other naturally-durable hardwood species be entirely neglected in such circumstances. Imported Australian hardwood sells at twice the price of our exotic softwoods, and, although New Zealand grown eucalypts generally still suffer under the commercial cloud imposed by *Eucalyptus viminalis* and *E. macarthuri*, there is every indication that selected species grown on the farm can match the imported product. Thus, the farmer should at least grow his own requirements of hardwood timber if he can. On many sites, indeed, these are the only species likely to thrive. Nevertheless, as location of the farm becomes more remote he should grow progressively higher proportions of the special-purpose durable species. The need, under these conditions, to concentrate any surplus over his own requirements on stems of maximum quality and intrinsic value can hardly be over-emphasized.

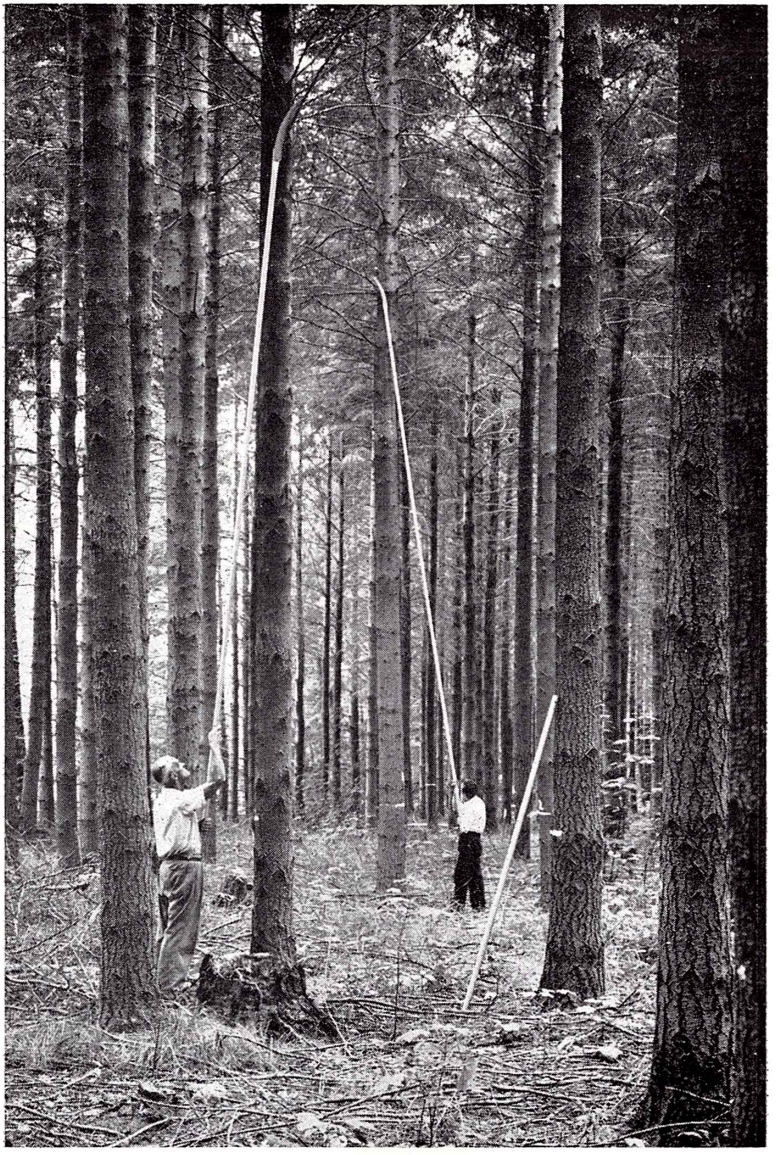


Photo by J. H. Johns, N.Z. Forest Service.

High prunning an exotic plantation with extensible tubular alloy-handled saws.

However, it is also necessary to consider well the opportunities for domestic self-sufficiency which are presented by simple preservative treatments such as cold soaking or diffusion techniques. These now permit ready utilization on the farm of much small produce in the round which would formerly have been wasted in plantations of general-purpose softwoods. Moreover, as types of portable sawmill are improved, and development of co-operative ownership (*e.g.*, by local Farm Forestry Associations) progresses, the handicaps of isolation will diminish.

This handicap has usually confined the direct benefits of woodlot management to domestically utilizable produce, by reducing the profits from outside sale as a source of regular annual income, supplementing that from pastoral production. Nevertheless, mature plantations can be a useful form of insurance against lean periods, and the statutory provision whereby this income may be spread over a period of up to five years is a useful one. It should also be specifically borne in mind that plantations, particularly if they have been given early silvicultural treatment, increase very much

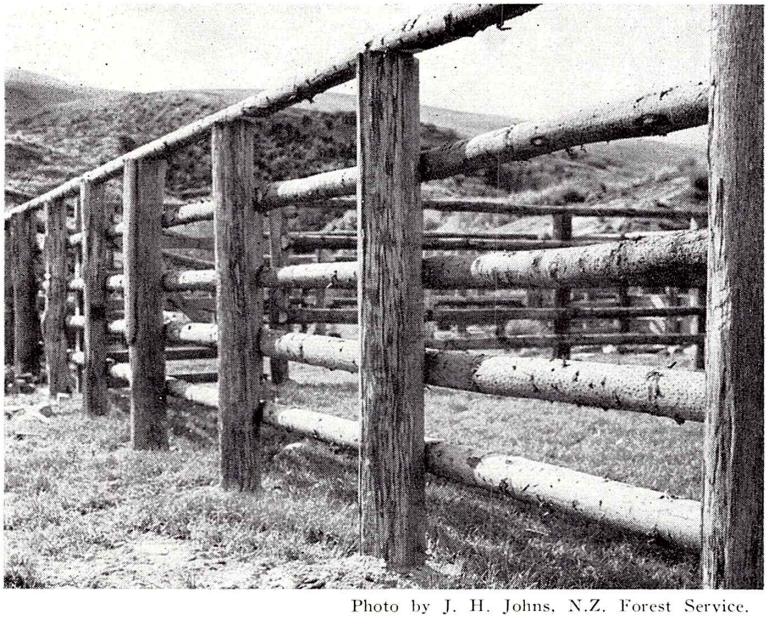


Photo by J. H. Johns, N.Z. Forest Service.

An example of utilization on the farm. A stockyard built of Norway spruce rails with posts made from old Australian hardwood power poles cut to required lengths.

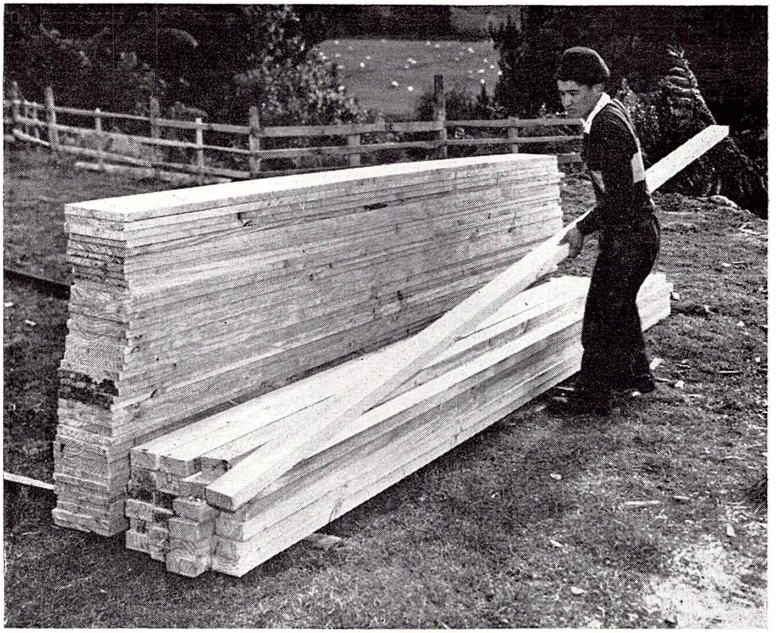


Photo by J. H. Johns, N.Z. Forest Service.

Farm grown radiata pine sawn as 9 in. x 1 in. and 4 in. x 2 in. timber being stacked ready for the merchant's lorry.

more in value during the second half of their rotation or life than during the first half. With the removal of death duties formerly payable on value of standing trees, there is every advantage in retaining trees to full maturity, so long as they are still growing vigorously and are not displacing young growing stock of potentially better quality.

Regeneration and Future Possibilities

Many older woodlots are now reaching the stage of maturity, and farmers are faced with the problems of establishing the second crop following logging. In many such areas there already exist groups of natural regeneration, ranging in size from seedlings to pole classes or larger. Such advance-growth has been encountered with radiata pine, Douglas fir, Lawson cypress (*Chamaecyparis lawsoniana*), western red cedar (*Thuja plicata*), and several species of eucalypts. The farmer has probably observed the much finer form and habit of young trees grown under these conditions than in normal even-aged plantation. It is well worth while favouring

such groups for the next rotation and using them as a nucleus for development toward a more uneven-aged crop structure. Such a form of woodlot management possesses several advantages for the farmer, over the more conventional even-aged stand:

(1) The form of stem and quality of the wood produced is much superior.

(2) A continuous supply of all sizes and types of produce is available.

(3) There is a lighter and more flexible annual work-load.

(4) Growth can be concentrated on the finest and most valuable stems to produce quality logs of maximum piece-size.

(5) Silvicultural tasks such as planting and pruning become minor activities supplementary to natural regeneration and self-pruning.

Moreover, the possibilities of integrating farm-forests managed under this system with existing groups of regeneration of many of the native species adds considerably to its attractions. Ther are, however, precluding its general application, several qualifications which should be mentioned. The first of these concerns the size of the area to be managed. It is probably not possible to create such a form of woodlot on an area much less than five acres, nor is it desirable for its extent to bear such a relation to available extraction routes that the distance from the latter to stump exceeds 2 or 3 chains. One of the principal problems with this form of management is that considerable foresight, skill, and care are needed during felling and extraction of mature trees, in order to minimize damage to groups of regeneration. The ability to visualize and maintain a correct distribution of tree-size classes in both space and time requires not only skill, but also that close personal knowledge of site and growth which probably only the owner-manager can provide. Such a farmer would be able to practise true farm-forest management.

DISCUSSION

Q:: *Are the available varieties of eucalypts reliable and true to type?*

A:: Yes, provided that they are obtained from registered nurserymen, using Forest Service seed. Quite apart from the frequency of hybridism among certain species of eucalypts, it is essential that all seed be collected only from trees selected for best possible form and vigour. Such assurance is provided by the sources mentioned.

Q:: *How high is it economic to prune radiata pine?*

A:: At present it is certainly remunerative to prune up to 18 ft, and the trend of current studies indicates that we may well extend this up to 35 ft or so. However, in terms of reducing the cost of this operation, the greatest economies are to be achieved by concentrating pruning on only the best and most vigorous trees in the stand.

Q:: *Do grass grubs damage young trees and should DDT-superphosphate be applied when planting trees in grass-grub infested areas?*

A:: Grass grubs can cause considerable damage to tree-stocks in the nursery, particularly of such species as Douglas fir. The damage can be controlled by applying DDT or Dieldrin (at 4 lb/acre in solution). This could be adapted to field-plantings by spot-application around the young trees, but with DDT-superphosphate care would have to be taken that the raw fertilizer did not come in contact with bare roots.

Q:: *What is the best method of treating timber on the farm?*

A:: The most simple and convenient methods are:

(1) Cold-soaking with standard creosote or 50% pentachlorophenol for posts and other round produce.

(2) For green sawn timber, the application of a borax/boric acid solution, followed by block-stacking under an airtight cover for 3 to 6 weeks. After this period of diffusion the timber is seasoned as usual.

Q:: *How is a multi-age tree stand started?*

A:: In old and maturing woodlots, by encouraging and tending existing groups of regeneration, extending them by marginal fellings (with plantings where necessary), and by creating new groups by patch-felling.

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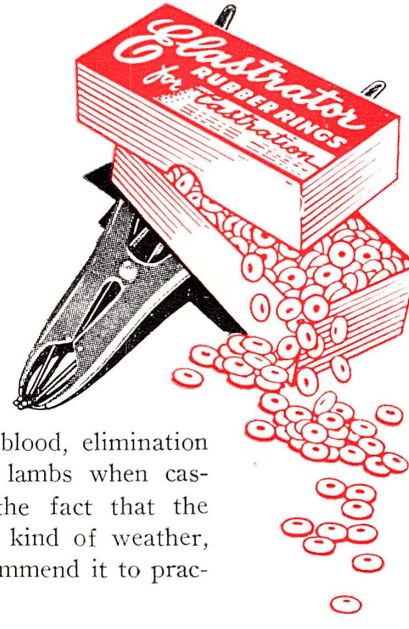

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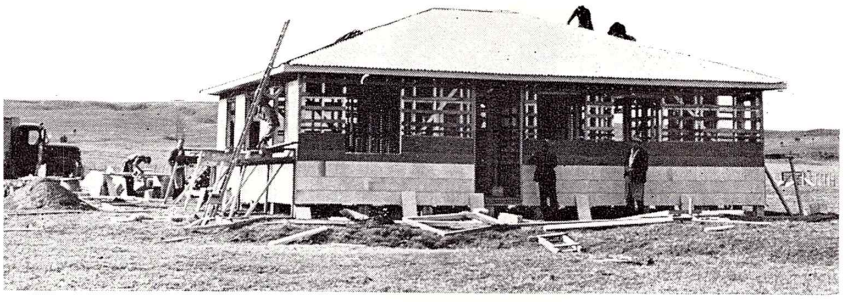

PROBLEM OF HOUSING FARM LABOUR

H. R. VINE*

RECENTLY a farm journal* ran a competition in which readers were invited to write letters expressing their thoughts on how farm labour could be made a more attractive career for young men.

There were about 400 letters submitted and in the process of judging they were sorted out according to the reasons given for labour being hard to get and retain on farms. The third most frequently mentioned reason was housing—either the low standard of accommodation provided for both single and married men, or the economic difficulty of many farmers in providing adequate housing.

Since these letters came from every district in New Zealand, and from every kind and class of farmer, both employing and employed, it seems reasonable to accept them as a fair representation of current farmer opinion—not a very easy thing to get.

According to nearly all of these (roughly 400) farmers, housing in the country is a very serious problem, particularly as it affects the supply of farm labour. Most of the letters which gave this opinion also gave opinions on what standard of accommodation might reasonably be expected by employees, and what employers must expect to provide. Some also gave suggestions of how this class of accommodation might be provided.

Accommodation for Single Workers

On the level of general opinion, these were the recommendations for single accommodation for farm workers:

*New Zealand Farmer, *Auckland.*

The single man's room should, preferably, be quite detached from the employer's house. It should not be less than 200 yd from sheep yards, shearing sheds, dog kennels, etc. It should be well lit, ventilated, and heated, decorated inside and out to the same standard as any modern homestead, provided with a power point for boiling a jug, and be furnished with floor covering, a good bed, dressing table, wardrobe, writing table, and an easy chair. There was a fairly strong recommendation, also, that it should have its own shower, washing facilities and flushing lavatory.

Since these amenities are the kind that young men nowadays have been brought up to regard as the perfectly normal accessories to civilized life, it would seem that anyone hoping to employ a young man has little justification for expecting him to do with less.

Even at today's prices, the cost of fitting out a room to these standards should not represent so great a capital investment that the provision of adequate housing for single men could justifiably be said to be a serious problem. If the general level of single men's accommodation on New Zealand farms falls below these standards, it is less likely to be for financial than for psychological reasons. It is probably not easy for some of the older generation, when considering what is reasonable by modern standards for single employees' accommodation, to keep their thoughts uncoloured by recollections of slab whare days when a cold tap outside the back door was pretty luxurious.

Accommodation for Married Workers

A good many entrants in the journal's competition, particularly female ones, gave details of what they considered adequate housing to offer a married couple; a good many also had comments about the economic hurdle confronting many farmers who have to provide this housing. The general opinion was that the standard of houses with which farmers could expect married employees to be satisfied is the same as that which urban workers consider normal—that is, the standard of houses which are being built by the thousand in new suburbs around cities; or alternatively, the standard of the typical State house.

These houses could not be classed as luxurious, but they all have the modern essentials, such as stainless steel or plastic-surfaced kitchen benches, plenty of built-in cupboards, plenty of windows, and plenty of bright paint.

Although its cost may be loaded by a building section valued at about £1,000, such a suburban house can be obtained by almost anyone these days for a very small deposit, or no deposit at all if a family benefit can be capitalized, and weekly payments amount to a very reasonable rental. Some figures from current statistics illustrate that many do this.

In 1949, the total number of permits for new dwellings in all rural districts was 9,854, and for all cities, boroughs, and town districts, 8,890—nearly a thousand more new houses for the year in the country than in the towns.

In 1959, the total permits for new houses in urban areas had gone up to 15,590 while in rural areas it was down to 4,978—over 10,000 more new town houses than country houses in one year.

In 1949, the value of new houses for the year was roughly equal in town and country; in 1959, the value of the year's new town houses was nearly £68 million more than the value of new houses built in the country.

The importance of these figures to farmers is that they demonstrate that the standard of housing described, being so readily available, has become, not only the normal, but actually the minimum standard, since no one needs to do with anything less. Indeed, suburban local bodies will scarcely allow anyone to build anything less. Married farm workers, or at least their wives, know this, and what has become normal for one industrial group is certainly normal for any other.

The question of whether or not an individual farmer can, in his particular circumstances, afford to build this kind of house for an employee, or whether he should build it, is obviously a matter for that farmer to decide for himself with, perhaps, the help of his accountant or his farm improvement club adviser.

If any general suggestion were to be offered, it should be that the question be thrashed out in the firm knowledge that the kind of home that has been discussed, the accepted suburban standard, should be the minimum standard; if a man has to compromise by building a sub-standard house because it is all he can afford, or because it is as good as his own, or for any other reason, the chances are he would be better in the long run not to have built one at all.

Financing Building

A very common suggestion by entrants in the Farm Labour competition was that the Government should be induced to apply the capitalization of family benefit scheme to the building of houses in the country for farm labour, so that rural industry would stand to benefit by the scheme, in the way that urban industry certainly does.

The family benefit scheme does, in fact, apply to family men in the country as much as in the towns, provided the same conditions as to standard of building, tenure of land and so on apply. However, in an employer-employee set-up, a house capitalized in this way can be for the use only of the employee whose family benefit provides the security, and cannot become a direct asset of his employer.

The scheme, therefore, is not of very much help in the problem of housing farm labour, because not very many farm employees want to buy a house while they are employees; most of them are waiting for the opportunity to have their own house on their own farm. It is generally a matter of policy with them that they move on from time to time to broaden their experience.

For a good many years the Government has provided some special facilities for financing country houses, though farmers have used them only spasmodically. Under the Rural Housing Act, 1939, and its amendments, county councils are empowered to obtain finance at 4 per cent. from the State Advances Corporation and to re-lend at up to 4½ per cent. to farmers in the country to erect housing accommodation on their farms either for themselves or for their farm workers. A loan of up to £2,000, including any suspensory loan which may be available, can be made to a farmer for each house, and repayment of the principal sum can be fixed on an amortization table of up to 35 years. To assist county councils in the operation of this scheme, the necessary valuations of the farms and proposed dwellings are made free of cost by the Government. In addition, the Corporation has available sets of plans and specifications which can be obtained by county councils at a nominal charge.

Finance schemes such as this one can never, of course, be the whole answer to the problem of providing houses for farm labour. At best they can make it possible for farmers who want to build, and feel justified in building an extra house but who have not the resources to finance the job themselves. There are still two other groups involved in the problem: those who want labour

but cannot get it because they cannot or will not realize that the accommodation they offer is well below normal standards, and those who need labour but who have little hope of paying for a new house even on the terms offered by a sympathetic finance organization.

There are no statistics available to show the relative importance of each of these groups in the problem of housing farm labour, so it must be an assumption only that there are, in fact, significant numbers of farmers who need labour but who cannot provide adequate accommodation because they cannot afford to do so. In considering this particular problem, reference will again be made to the entries in the Farm Labour competition, because one particular solution was suggested by a surprisingly large number of competitors. That so many farmers from so many different districts should have been thinking along these lines is surprising because the idea offered is quite a revolutionary one, cutting right across traditional thinking about the housing of farm labour in this country.

Non-resident Labour as a Solution?

The suggestion is that a trend away from providing accommodation for farm workers on the farms should be developed, and that, instead, the aim should be to have farm labour living in rural villages or country towns and travelling to and from work at more or less regular hours, as is done commonly by farm workers in Britain, and by suburban commuters in New Zealand cities.

To illustrate the sort of suggestion that many entrants made, extracts from one letter are quoted: "Is it necessary for a man to live on the farm, where he and his wife must inevitably come under the domination of the farmer and his wife? If the employee lived off the place, tiny bits of friction would not build up and spark off the row that sends the man looking for another job.

"With good roads and modern transport, a man can live eight miles away and still spend less money and do far less time travelling than thousands of city workers.

"On dairy farms the dairyman, if single, could have breakfast and lunch with the farmer and board at home, where he would be far happier than with the farmer.

"If State houses were built in all the settlements that dot the rural areas, many more families could be induced to settle in the country. Perhaps legislation could be passed to allow individual

farmers to guarantee the rent of a State house in the same manner as the farm labour schemes. This doesn't solve the back country farmer's problem, but what proportion of farms are today eight miles from a small settlement?"

The points in favour of the suggestion, summarized from the letters of other people who made it, are briefly:

(1) By making it possible for farm workers to rent houses, provided either by the State or by some kind of group housing scheme, it would absolve farmers from being individually responsible for the provision of houses.

(2) It would remove the hazards to farm employment of the social conflicts that sometimes arise through an employee being dependent on the owner's ideas of what constitutes adequate housing.

(3) It would help to lessen the problems arising from the social isolation which is commonly a drawback to farm employment, particularly from the point of view of the farm worker's wife.

The idea obviously has more chance of usefulness in relatively closely settled dairyfarming districts than in sheepfarming districts, and it is not necessary for the obvious weaknesses of the scheme to be discussed in detail here. The main problem is that there are still many country roads that are not good, and the cost and inconvenience of travelling to and from work probably would not be as simple a consideration as most dairyfarmers on tar-sealed highways may think. Even there, the position is not quite analogous to that of the suburban commuter because there are no regular and frequent bus or train services in the country as there are in the suburbs.

But despite these and the other drawbacks the idea does have enough merit to warrant consideration.

DISCUSSION

AT THE CONCLUSION of this paper, the chairman invited discussion on any aspect of farm labour, whether directly related to the theme of the paper or not.

The general opinion appeared to be that some positive corrective measures were necessary to make working and living in the country more attractive and secure. Amongst the ideas put forward were:

(1) A higher standard of accommodation on farms.

(2) A superannuation scheme for farm workers.

(3) The organization of farm villages stragetically located in rural areas to facilitate:

(a) Workers owning their homes, if desired.

(b) Creating a social environment more attractive in that the workers and their families would no longer be isolated from their fellows as is usually the case when living on the farms.

(c) Provision of State housing to the rural community on more or less equal terms to that enjoyed in the cities. This would enable the farmers to compete more favourably for labour and obviate the need for very high capitalization of farms to provide accommodation for workers.

(4) Government schemes making it possible for farm workers who have limited initial capital to obtain their own farms eventually.

(5) Higher wages for workers.

(6) Better facilities for those living in the country to educate their families —perhaps financial assistance from the State as well as provision of better amenities.

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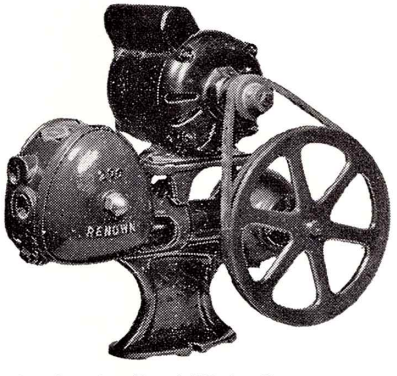

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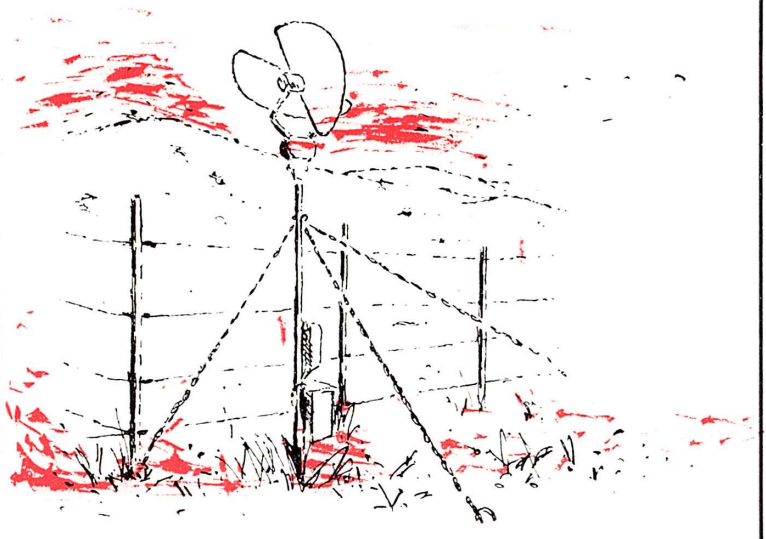

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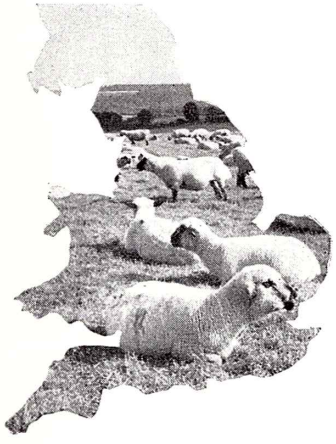
Summary

A LOOK AT BRITISH AGRICULTURE



G. S. ROBINSON*

A REVOLUTION in agriculture took place in Britain during the war years when the necessity for stepping up production was apparent to everyone. But this revolution did not end with the cessation of hostilities, and the improvements which have taken place in British farming in the last 15 years are just as outstanding as the earlier ones. Many New Zealanders have reported their impressions and the various reasons for the progress in British agriculture. Although Britain's climate and other farming conditions are different from those of New Zealand, many aspects of crop and pasture husbandry are similar and could find application here. The following are some impressions gained from a visit in 1960.

Cropping

British cropping techniques have always been highly regarded and yields per acre continue to rise. High fertilizer usage, especially nitrogen, has much to do with this and is having the effect, too, of permitting more cash crops to be grown in the rotation. The new chemical weed control methods have played their part where weeds would otherwise prevent this extended cropping.

Grassland

Two aspects of grassland framing in Britain have contributed to its increased production. First, pastures are now generally recognized as a valuable source of stock feed, thus reducing the quantity of crops to be grown and protein meals bought in.

**Massey Agricultural College, Palmerston North.*

Secondly, nitrogen and other fertilizers are being used on an increasing scale and appear to be much more necessary under the climatic conditions prevailing in Britain than they are in New Zealand. Tremendous interest in grassland management is noticeable everywhere and many counties have their own grassland associations furthering progress in this field.

Land Development

Although most of the derelict land that had fallen into disuse prior to World War 2 has now been brought back into production, there still remains a big area of upland country which is capable of improvement. This is being held up very largely because of tenure, much of it being Common Land that cannot by law be enclosed. Technically, much of this land would make good sheep grazings. In comparison with New Zealand hill country, it is generally easier in contour but the soils are more acid. However, with ample subsidies available, increased development is a distinct possibility in the future.

Silage and Hay

Great developments are afoot in the pasture conservation field. As in New Zealand, improved hay quality is being obtained by increased mechanization, and early and frequent turning of the hay. Much improvement still remains to be done, but the hastening of the drying process is reducing the wastage normally associated with unreliable summer weather conditions.

Silage making has also progressed, the greatest development being in the methods of storage. Covered trenches suitable for self-feeding are in evidence in many districts, and once again advantage is being taken of a generous subsidy to alter buildings for this purpose.

Grass and Clover Seed Production

Seed production appears to have become less widespread and many growers in districts with doubtful weather conditions have dropped out of production. Methods have improved, and growers are generally producing a good quality product and high yields per acre. Two aspects are worthy of note and could find application in New Zealand. First, greater use of nitrogen in grass seed

production could be made and, secondly, further investigations should be made into the effect of sowing methods and rates of seeding on yields.

A visitor leaves Britain with the feeling that agricultural research and education are thriving, and that the outstanding increases in production achieved in the last twenty years are showing no signs of tailing off. With the encouragement that farmers are receiving, these developments can be expected to continue.

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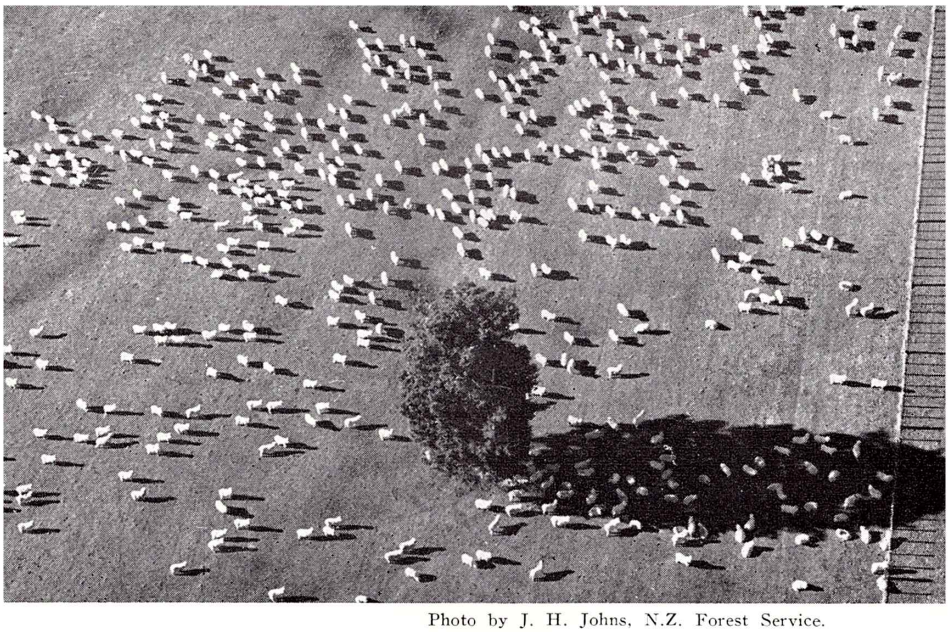

Photo by J. H. Johns, N.Z. Forest Service.

GROWTH RESPONSE TO SELENIUM IN LAMBS

T. G. ROBERTSON*

DURING the past two years, the Department of Agriculture has carried out an extensive investigation to measure the effects of treating lambs with cobalt and selenium. Investigations into the causes of lamb ill-thrift have been going on for some time, mainly carried out by officers of the Wallaceville Animal Research Station in areas where the effects are serious, such as the Rotorua-Taupo pumice country. However, because there was also the possibility that a milder form of deficiency might be present in other parts of the country, this series of trials was designed.

Since the project started, over 600 trials, each measuring lamb liveweight gains over a period of about three months, have been conducted; this season's total is not yet complete. As there are, on the average, about sixty animals involved per trial, this means that between thirty and forty thousand animals have been used. This, therefore, is probably one of the largest projects of its kind ever carried out in this country, or overseas.

*Farm Advisory Division, Department of Agriculture, Wellington.

The project started in the autumn of 1959, when just under a hundred trials were carried out in Canterbury. Mostly these compared cobalt-bullet-dosed lambs with untreated ones, but several also included selenium and copper treatments. The following season, 1959-60, the project was extended to cover the whole country. A little over three hundred trials were conducted, split more or less equally between the two islands. In these, the standard trial consisted of four groups—an untreated group, a group receiving a cobalt bullet monthly, a group treated monthly with selenium (5 mg by mouth), and the fourth group receiving both cobalt and selenium. Many of the trials varied slightly from this, some testing other factors also, such as copper, and some comparing cobalt given as a sulphate solution with cobalt given as a bullet.

From the season just finishing, over 200 trials have come in so far, and the list is not yet complete. The design for this year's set was basically the same as for the previous season. In addition, a number of trials of selenium only were carried out on unweaned lambs. Another cobalt bullet, thought to be an improvement on the one used earlier, was used, but only one of these was given to each animal, instead of one per month as previously. Selenium was still dosed monthly but the rate was reduced from 5 mg to 1 mg. The available results for this season agree well with last season, and it is unlikely that those still to come in will show any major differences.

Results

Cobalt

No large-scale areas have been discovered where a cobalt deficiency occurs which was not previously known. Many of the areas which have been known to be cobalt deficient in the past now appear to be no longer deficient. Over the years, a considerable amount of cobalt has been applied in these areas and the deficiency may now have been overcome, at least temporarily. Indeed, no major area or soil group in this series has shown consistent cobalt responses. Cobalt, however, leaches out of the soil and any balance that may have been reached is probably a precarious one. The series did show that there may still be small pockets where a cobalt response may be obtained. There was one spectacular example of this at Matamata this year. The cobalt-treated animals gained 19 lb over $2\frac{1}{2}$ months, while the untreated animals gained only 5 lb.

What has shown up in general, though, has been a small but fairly general depression in liveweight gains to the cobalt treatment. It has been suggested that this may be due to the presence of the bullet itself, and that the effect may not show up if cobalt is supplied in other ways. On the other hand, the group of trials in the series which compared cobalt given as the sulphate drench, with the bullets, showed depressions of about the same size to both.

While this does not necessarily mean that farmers should stop applying cobalt in any form anywhere, it does mean that they should not be applying it indiscriminately to the animal as a drench or bullet. Further work is needed to look at the effect of applying cobalt as a topdressing. Meantime, a good rule would be that they have a talk to the local Farm Advisory Officer before starting to use cobalt on a farm for the first time.

Copper

Copper was included as a treatment in a number of trials. A few showed responses in weight gains, and one or two showed depressions. Most showed no effect. It is known, though, that liveweight responses to copper are rare. Response to copper drenching where marked deficiencies exist is shown in other ways, such as in the quality of the wool grown, especially on Merino sheep.

Selenium

Selenium responses in the trials were widespread—right from Kaitaia to Invercargill—and there were few depressions in liveweight growth. Although this picture is general, the degree of response does depend on the type of soil. The trials have been sorted into groups according to a fairly broad soil classification—14 such groups in the North Island and 12 in the South. Some of these contain trials of which nearly all show good gains from selenium, and range down to some, which, on the average, show no response at all. Not one of these major groups showed a depressive tendency. There were, of course, some individual trials which showed depressions to selenium, and the reasons for these will be discussed.

Good responses were shown in most parts of the South Island. In fact, the only South Island groups not showing good responses are ones in which there have been relatively few trials—*e.g.*, the saline soils and soils of volcanic origin. These are fairly small in area, and very little information has been gained on them, even

from a project of this size. Further work is needed on these to clarify the position.

In the North Island there were good responses on the coastal sands and on the central pumice soils. There were slight responses in soils in 30 to 40 in. rainfall areas, such as those round Massey College and Marton which have compacted subsoils and relatively poor drainage. There were also extensive areas of the North Island where selenium responses were small or nil. These occurred, for instance, on soils in areas with rather higher annual rainfall than those just mentioned (say, 40 to 50 in.), and in which drainage is not such a problem. The other major groups not showing consistent responses were soils of volcanic origin, other than pumice.

There was one group of trials, on pumice, round Whakatane which did not show a selenium response. The interesting point is that this pumice is not derived from the Taupo ash shower as are others where the responses were obtained. But even those derived from the Taupo ash showers are variable; for instance, the response round Wairoa was fairly small.

Soil group, then, accounts very largely for the differences of degree to which responses to selenium occur, but there are other factors which may affect them. For instance, the trials tended to show better responses to selenium when the untreated animals were doing well, than when they were doing poorly. With an average weight gain in the untreated group of, say, 20 or 30 lb, the extra gain to selenium might be 3 or 4 lb, but where the untreated group was almost stationary in weight gain, selenium did not seem to improve the animals in general, and in many cases appeared to make them worse. The mechanism causing this is not understood, but it works the opposite way to what might be expected if selenium was a limiting factor to growth.

The trials were examined for association of responses with other factors, such as food supply, soil moisture, and previous cropping or topdressing, but no relationships were evident. Very few of the trials were on areas which had been cropped in the last two or three years, and soil moisture as assessed did not vary greatly over the trials.

The possibility of the responses being related to the time of treating the animal was also examined. There was no noticeable association of time of treating with size of response over a three-months' period, but clearly if the animals are treated earlier they

will have the advantage of selenium for a longer period. The important point is that treating even quite young lambs did not harm them, so that selenium can be given quite soon after birth. Ewes treated with selenium tended to produce better lambs, and even their lambs benefited from treatment later on.

These trials have not dealt in any detail with optimum dose rates, being concerned more with finding the areas where the treatments are beneficial. Detailed trials on dose rates and times of administration are being carried out in a separate project by the Wallaceville Animal Research Station.

It should be stressed that, although the responses to selenium are widespread and consistent, selenium is not the answer to everything. For instance, it does not have a beneficial effect on the autumn flush ill-thrift so common in some parts of the North Island in some seasons. As previously mentioned, where there is trouble of this form occurring, and the animals are not gaining, selenium is not of any advantage and is perhaps harmful.

Summary

Cobalt, when dosed to lambs, has given very few responses and may in some circumstances depress growth slightly. Further work is needed to see whether cobalt applied as a topdressing produces similar results in lambs.

Copper has not given many responses, but was not expected to while the measuring unit was liveweight gains.

Selenium deficiency has been found to be widespread throughout the country, quite apart from those areas already known to be deficient from the occurrence of white muscle disease and barrenness in ewes. The main soils which do not appear deficient are those of volcanic origin other than the central North Island pumice country.

DISCUSSION

Q:: *Could the speaker elaborate on the trials with selenium in which a depression in liveweight resulted?*

A:: There were only a few. There were only two greater than 3 lb, one last season and one this. No area showed consistent depressions. Those which did occur did not appear related to any particular factor. They were probably just chance effects arising from the way the animals happened to be grouped for treating.

Q:: *Have you any results on the use of selenium to increase the lambing percentages of ewes?*

A:: Not from this particular series. Other trials conducted by Wallaceville Animal Research Station on the pumice have shown marked increases.

Q:: *What is the cost of drenching a lamb with selenium?*

A:: The actual cost of the material itself is very slight—usually only a fraction of a penny per sheep—but labour costs in giving the drench must also be considered.

Q:: *Has the amount of selenium that accumulates in the animal after administration of this element been determined?*

A:: Because selenium occurs naturally, it is always present in small amounts, even if not artificially administered. New Zealand pastures appear to be low in selenium and we are only trying to make up the difference. Work at Wallaceville shows that, at the recommended rates of administration, there is no serious accumulation of selenium in animal tissues. The very small amounts present in animal produce could constitute no hazard to humans.

Q:: *What is considered a "significant response" in growth rate following selenium drenching?*

A:: We use the term "significant" in a special way in statistics. It means that the observed difference is likely to be due to treatments and not just because the "better doers" tend to be in one group rather than the other. Although the difference may be due to treatment, it may be quite small. The size of response we can show as "significant" depends on the size of the trial. In this series of trials, differences of 2 or 3 lb in weight gain were "significant" in the statistical sense. From the farmer's point of view, the gain must be of economic value as well as being "significant" and this depends on the cost of administration and value of the extra return.

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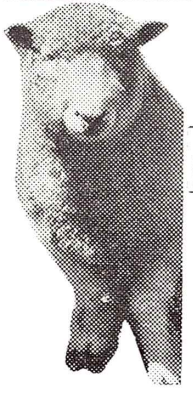

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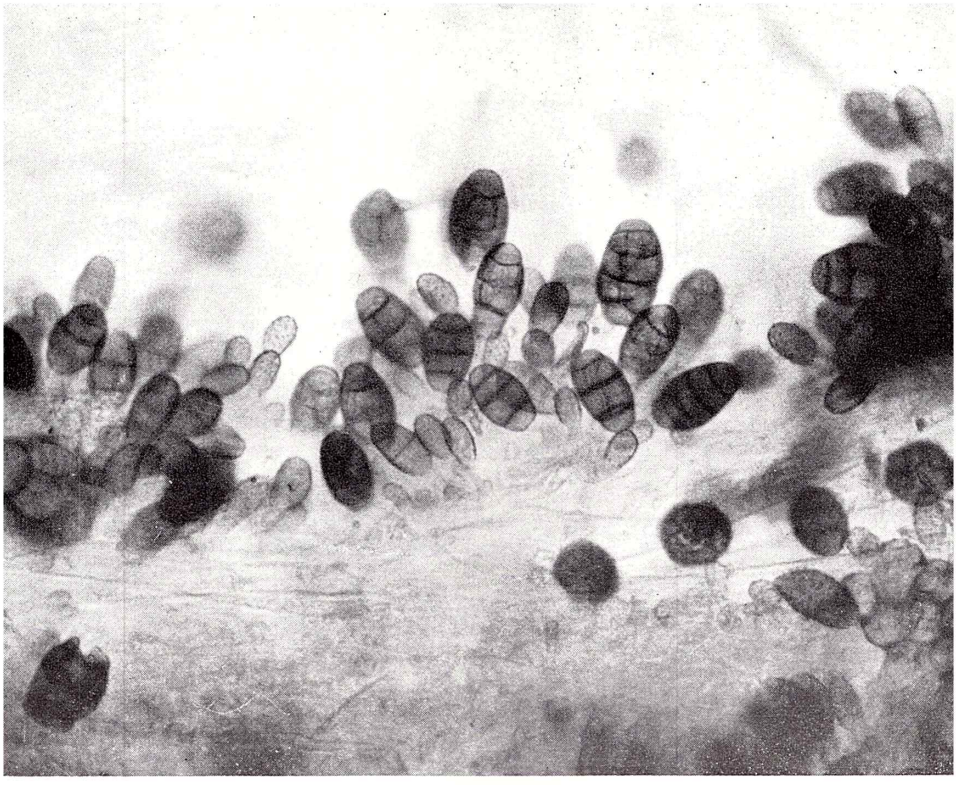

Fig. 1: Pithomyces chartarum *growing on a ryegrass leaf. The leaf tissue is covered by hyphae which are producing spores at all stages of development up to fully mature. (Magnified 500 times.)*

THE FUNGUS PITHOMYCES CHARTARUM AND FACIAL ECZEMA

P. J. BROOK*

In 1958, Thornton and Percival first broke the news that a fungus could be implicated in facial eczema disease. Since that time, most thinking, or at least most public thinking on facial eczema, has been in terms of this fungus.

It is proposed, in this paper, to put the fungus into a more correct perspective.

The earliest mention of facial eczema occurs in veterinary reports in 1897. Since that time the disease has become fairly well known in many parts of the North Island, and occasionally in

**Plant Diseases Division, D.S.I.R., Auckland.*

Nelson and Marlborough, but not farther south. From time to time there have been bad outbreaks. The worst was in 1938, when stock in Waikato, Poverty Bay, Hawke's Bay, Manawatu, Wanganui, Taranaki, Auckland, and Northland were affected in large numbers.

Although there have not been very many serious, widespread outbreaks, every year the disease occurs to some extent. A few districts are notorious for outbreaks every year.

Facial eczema usually shows up in autumn, during February, March or April, but sometimes it occurs as early as January, or as late as May.

The characteristic clinical symptoms of facial eczema are photosensitization and jaundice. In sheep, the onset of visible symptoms is usually sudden. The sheep stamp their feet and shake their heads. They move about in the paddock much more than usual, and will rub their heads against fence posts. Their facial skin is evidently irritated. They also seek any shade that is offering, even to the extent of pushing their heads into hedges. At Manutuke Research Station, affected lambs have been known to run alongside a tractor in its shade while the paddocks they were in were being mown.

Swelling of ears, eyelids, face and lips soon develops. In fact, the first sign usually noticed in sheep is the swelling of the ears which causes them to droop. The whites of the eyes become inflammed and yellow, and the sheep may become temporarily blind. There is a seepage of serous fluid from the skin swellings, and affected areas become covered with scabs.

These symptoms of photosensitization develop only in skin through which the activating light rays can be transmitted—that is, the uncovered white or light-coloured areas. Thus, for instance, photosensitivity has not been seen in Aberdeen Angus cattle that are black all over. Amongst cattle, the skin lesions develop on white parts or on lightly coloured parts like the pale yellow areas of Jersey cows.

In milking cows, whose teats and udders are more pronounced than those of beef cattle, the first symptom of the disease is an irritation of these parts. This is followed by swelling and scabbing of the teats and udder. Cows in this condition cannot, of course, be milked, and have to be dried off.

It was found quite early in the work on facial eczema that these external symptoms, that earned the disease its name, are not the

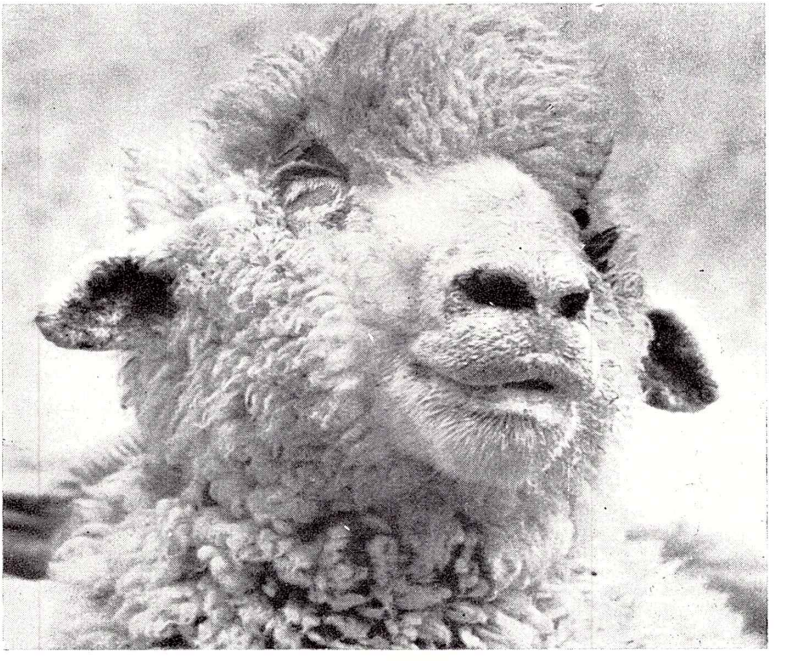

Fig. 2: Sheep with facial eczema. Note swollen lips and nose, drooping ears, and abrasion around eyes.

major damage caused by the disease at all. In fact, facial eczema is really a disease of the liver.

The liver of a sheep or cattle beast suffering from facial eczema becomes tough and fibrous; its shape may be grossly distorted. It is blotchy in appearance, and in severe cases it may be of a green or yellow-green colour.

This fibrous condition is brought about by the thickening of the walls of the intermediate-sized and larger bile ducts in the liver. As the liver condition worsens, capillary bile ducts disappear. Intermediate-sized bile ducts become blocked by solidified bile or by growth of their own wall tissue. Parts of the liver tissue die.

The failure to function of a very seriously affected liver results in death of the animal. However, the liver has a capacity to regenerate its tissue, and in less severely affected cases the production of fresh liver tissue can keep the sheep or cattle beast alive.

Once it was established that the liver damage and the skin symptoms were one and the same disease, a connection between

the two was sought, and found. In 1942, Cunningham, Hopkirk and Filmer identified phylloerythrin in the blood of sheep that had facial eczema. In 1944, Clare completed this part of the work.

Phylloerythrin is a breakdown product of chlorophyll, the green pigment responsible for photosynthesis in plants. Phylloerythrin is found in the digestive tract of many herbivorous animals, and normally is excreted in faeces. Some is absorbed from the gut into the blood and is taken by the hepatic portal vein to the liver. In the liver it is excreted into the bile and so proceeds by way of the main bile duct into the duodenum.

Because the system of smaller bile ducts is blocked or destroyed in the liver of a sheep suffering from facial eczema, the phylloerythrin cannot be excreted out of the blood into the bile. It is therefore carried in the blood system throughout the whole body.

Phylloerythrin is a photosensitizing pigment; when it reaches areas like the unprotected facial skin, exposure to sunlight produces the characteristic lesions. This is not the same as sunburn. Symptoms of facial eczema are produced by sunlight in the visible spectrum. True sunburn is caused largely by ultra-violet light.

Although by 1944 it was known what caused the dermatitis, that is, the external symptom of facial eczema, it was still not known what caused the breakdown of the liver. The action of phylloerythrin is only a secondary effect.

Over the years it was noticed that outbreaks of facial eczema followed warm autumn rains. The most severe outbreaks occurred when there had been a hot dry summer, a drought in fact, that depressed pasture growth; this was followed by a spell of warm rains. The disease struck most often in high-fertility ryegrass pastures.

Warm autumn rains bring on new grass growth. It was naturally suspected that facial eczema was connected with the rapid growth of ryegrass just after these rains. For many years, at Ruakura Animal Research Station, Hamilton, and at the Manutuke experimental farm near Gisborne, large quantities of grass were collected from paddocks in which facial eczema had occurred. By feeding to sheep it was found which samples of this harvested grass were in fact toxic. Grass samples known to contain the toxic substance were then examined by chemists in an effort to isolate the active chemical.

A chemical test, called the "beaker test", that could be used with a fair degree of accuracy to determine whether or not a

pasture was toxic, was worked out. The beaker test involves extraction of the grass sample with various solvents, the last of which, when evaporated off, may leave a white deposit on the side of the beaker. Absence of this residue indicates that the grass is non-toxic. The density of the deposit indicates, to a rough degree, the amount of toxin in the sample. That is, it indicates whether sheep grazing in the paddock are likely to contract facial eczema, and if so to what extent, within rather wide limits. It was found, however, that the white deposit, known as the beaker test substance, was not the toxin itself.

Testing samples for toxicity by feeding them to sheep is an expensive and awkward business. But for any chemical work aimed at isolating the toxin from grass samples, it was essential to have a reliable test for the presence of the toxin. It was found that young guinea-pigs that were fed toxic grass developed characteristic liver damage in 3 to 4 weeks. In the laboratory at Ruakura, therefore, guinea-pigs were used for this work.

Obviously, any chemistry that requires testing at every step, by a four-weeks' programme of feeding to guinea-pigs, will not produce results in a few days. By patient work, Dr E. P. White developed a method of concentrating the toxin in grass samples so that practically the whole of the toxin present in the original grass sample is contained in a fraction that is 1/70,000 of the original weight. This method employs nine steps and involves a considerable amount of rather complicated chemistry.

At the Plant Chemistry Division, D.S.I.R., Palmerston North, this method was brought up to production line standard, and several tons of grass were processed.

In 1958, things took a sudden turn for the better. Dr R. H. Thornton, of Soil Bureau, and J. C. Percival, of Ruakura, showed that a fungus they had isolated from grass on the Claudelands Showgrounds, in Hamilton, caused typical facial eczema when it was fed to lambs. They had selected this particular fungus out of a large number they had isolated because it gave the beaker test characteristic of toxic grass.

The fungus is called *Pithomyces chartarum*. The fungus was formerly called *Sporidesmium bakeri*, but recent studies have shown that the characteristics of its spores, and the way they are produced, are not really similar enough to those of the other species of *Sporidesmium* for the fungus to be grouped with them. In fact, the fungus is much more like some species of *Pithomyces*, and so it has been given the new name *Pithomyces chartarum*.

It has already been mentioned that it was known prior to the discovery of the fungus that the beaker test substance was not the toxin itself. Dr D. W. Russell, Plant Chemistry Division, has since tidied up this point. Briefly, the beaker test substance is a crystalline chemical material found on the spores of the fungus. In extracting a pasture sample for the beaker test, the amount of this crystalline material obtained will therefore depend on the number of spores of the fungus that were in the sample. That is, the more spores of *Pithomyces chartarum* there are in the pasture sampled, the greater will be the beaker test deposit.

With the discovery of Thornton and Percival, the whole of the work on facial eczema gathered a new momentum. A supply of the toxin for chemists to work on could be made available simply by growing the fungus in pure culture in the laboratory. This replaced the arduous collection of large amounts of toxic grass. The chemists were also able to simplify their extraction methods, since they no longer had to remove large amounts of substances from the grass material. It was found that about 0·05 per cent. to 0·1 per cent. by weight of the fungus was toxin. It was therefore possible, by growing enough of the fungus, to produce visible amounts of pure crystalline toxin instead of the minute amounts of toxin that could be obtained from grass. In a few months a tentative empirical formula for the toxin was worked out:

$$C_{18} H_{22} Cl N_3 O_6 S_2$$

The name coined for the toxin is sporidesmin.

One avenue of work that has profited greatly from the production of purified toxin in the laboratory has been the study of the disease in the animal. Exact doses of pure sporidesmin have been given to animals, and the effects studied closely.

Small doses of toxin cause no visible damage to the liver, but the animal tends to go off its food for a few days after receiving the dose. Then it recovers its appetite. At moderate dose rates, the characteristic liver damage develops, showing up in about a fortnight. This is the normally observed condition of facial eczema.

After a heavy dose of sporidesmin, an animal dies within a few days. With such a comparatively sudden death, visible liver damage does not have time to develop. It is plain, now, that this toxin, sporidesmin, does not cause physical damage only to the

liver. It also interferes with the chemical functioning of the liver tissue. A heavy dose, therefore, interfering immediately with the proper functioning of the liver, results in rapid death of the animal.

It was fairly quickly established that *Pithomyces chartarum* can cause facial eczema—that is, that the fungus contains a toxic substance which, if eaten by a sheep, brings on a condition typical of facial eczema. But it took rather longer to establish that this fungus is, in fact, the major or the sole cause of facial eczema in the field.

This fact has been established by D. P. Sinclair, at the Manutuke Research Station. Groups of lambs were grazed in different fields for periods of several weeks. Throughout the grazing periods, estimations were made of the numbers of spores of *Pithomyces chartarum* in the different pastures used. At the end of each grazing period the lambs were killed, and their livers were examined for damage typical of facial eczema.

A remarkably good correlation was obtained between the numbers of spores in a field and the severity of the liver damage in lambs grazing there. The more spores there were, the greater was the degree of facial eczema suffered. When there were no spores, or only small numbers of spores, there was no facial eczema.

It can be said now that facial eczema is caused by *Pithomyces chartarum*. This fungus, growing in the pasture, contains a toxin that has been called sporidesmin. When a sheep eats the fungus it gets a dose of the toxin which, according to the size of the dose, will bring about a greater or lesser amount of liver damage.

With this establishment of the connection between the fungus and the disease, it can now be fairly concluded that anything known about *Pithomyces chartarum* will have some bearing on facial eczema.

Since the fungus growing in a pasture cannot be seen without a microscope, it is necessary to form a mental picture of the process that is going on in the grass.

Pithomyces chartarum is a mould—that is, it grows out more or less haphazardly without ever organizing itself into any definite form. This is different, for example, from the mushroom. The vegetative part of *Pithomyces chartarum* is a fast growing, branching and spreading tangle of extremely fine living threads called hyphae. The hyphae grow through the food supply, absorbing nutrients from around themselves.

Some hyphae grow out over the surface of the food supply, and on these exposed hyphae the spores are produced. The spores appear as outgrowths along the hyphae, and are dark brown or black; they are more or less barrel-shaped, and measure roughly a thousandth of an inch along their longer axis. When a spore is ripe, it breaks off and is blown away.

Spores, of course, are the reproductive bodies of fungi. They perform the same job as seeds in green plants. When a spore lands on a suitable spot, and conditions are wet enough, it germinates by putting out a germ tube. The germ tube soon grows, and as long as conditions stay favourable and there is plenty of food, the germ tube rapidly develops into the tangle of hyphae that constitutes a new plant of the fungus. In time, new spores are produced on some of these hyphae.

When everything goes well for the fungus, the time elapsing between the germination of a spore and the ripening of the first of a new crop of spores is about 4 or 5 days.

By observing the habits of any fungus, it is found that there are three major factors that affect its growth and spore production, namely, the substrate, which is the food supply, temperature, and moisture. This is, of course, equally true of all plants.

For each species of fungus there are particular conditions of food supply, temperature, and moisture that suit that species best. There is a fairly large company of fungi that can live in pastures, and each of the different species prefers a particular set of conditions. There is, in fact, a high degree of competition between different fungi for living space in the sward. For any one of them to be able to multiply up to the stage where it is the dominant species, the conditions of the environment have to be just right for it.

Pithomyces chartarum has the following environmental requirements:

SUBSTRATE

This fungus will grow only on dead plant matter; it is incapable of attacking living plants. It can, however, use the dead material of most, if not all, of the plant species normally found in pastures, including grasses, clovers, and weeds. For the fungus to thrive in a pasture, that is, for it to go on growing strongly, producing large numbers of new spores, a continuing supply of dead plant tissue must be provided. These conditions occur, of course, in a field that is being continuously grazed.

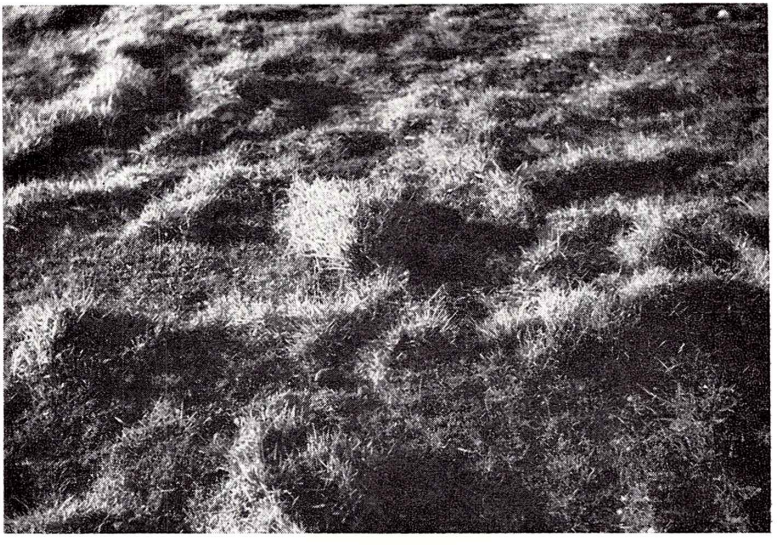

Fig. 2: Tussocks of Yorkshire fog in a pasture. Other species have been eaten down, but the Yorkshire fog with its abundant dead leaf material remains, providing an excellent growing place for Pithomyces chartarum, *and a reservoir of the fungus.*

The more plant debris that is provided, the better the fungus thrives. It is now well known that pastures that are mown regularly and often, such as race courses, golf links, and show grounds, support very high populations of *Pithomyces chartarum*. Widespread death of plants during drought provides a supply of suitable material. An excellent promoter for the fungus is the black beetle which is widespread in Northland, and whose root feeding in pastures leaves behind great patches of dead plant material.

Temperature

It has been found from studying the fungus in the laboratory that the optimum temperatures for growth and for spore production lie in the upper seventies Fahrenheit. In comparison with the temperatures preferred by some of the other fungi found growing on pasture debris, the temperature optimum for *Pithomyces chartarum* is high. Sustained periods of temperatures in the upper seventies within pastures are more or less confined to summer and early autumn, and, even then, only in more northern districts of New Zealand.

Thus, it is found that the really vigorous growth of *Pithomyces chartarum* takes place in summer and early autumn, and that the active outbursts of fungus development occur in the warmer districts of the North Island and the northern tip of the South Island.

At other times of the year, and in other districts, *Pithomyces chartarum* can often be found growing, but only at a considerably reduced rate. Its fungus competitors, with their better ability to thrive at lower temperatures, are able to beat *Pithomyces chartarum* to the available food.

Moisture

It has been found, again in the laboratory, that the successful germination of spores, and the establishment of hyphae from them in leaf debris, need a period of about 24 hours of 100 per cent. relative humidity. Although established hyphae can go on growing inside leaf debris, even during prolonged spells of dry conditions, new spores are not produced until the atmosphere around the debris becomes very damp again.

In the field, therefore, a rapid build-up of the fungus is associated with a period of rains, or of very humid weather, usually lasting for several days. During prolonged damp spells, the fungus can be found growing and sporing freely on debris exposed at the top surface of a pasture and also on pasture debris covering otherwise bare ground—the sort of condition brought about, for example, by drought, or by black beetle damage.

Under more normal summer conditions of brief rainy spells and longer fine periods, growth of the fungus tends to be concentrated in debris scattered in the base of the pasture, that is, in a zone of the pasture where the cover provided by growing plants maintains beneath it a high humidity.

The conditions that promote a vigorous development of *Pithomyces chartarum* are those conditions that have been associated over the years with outbreaks of facial eczema. Farmers have learned to regard spells of warm, rainy weather in summer and early autumn, especially when such wet spells follow drought, as being responsible for facial eczema. It is now known that the combination of abundant dead pasture matter, high temperatures, and damp weather, does, in fact, bring on an intense growth of *Pithomyces chartarum*.

Once the fungus is established in great quantities in a pasture it does not disappear overnight. If the weather becomes less favourable, rather cooler, say, or drier, because *Pithomyces* has already

swamped its competitors, it can hold on for a time, still growing fairly well, and still producing new spores. When the weather becomes more favourable again, there is a new increase in the activity of the fungus.

In some places and in some seasons, the population of *Pithomyces chartarum* stays very high in pastures for quite a long period. For example, in two fields near Dargaville that were examined in 1960, the amount of *Pithomyces* stayed at a level regarded as dangerous to stock for the whole of the period from February 8 until April 26.

This conception of the possibility of a more or less continuous prolonged period of activity of the fungus must be taken into account in the thinking to be done on control of facial eczema.

Control of Facial Eczema

To the best of the writer's knowledge there have not yet been any discoveries in the research on facial eczema that could be used directly to work a miracle cure. For instance, there has not been a fungicide that could be of practical use in controlling *Pithomyces chartarum*, though quite a number have been tested. Although considerable effort is being devoted to finding a vaccine, there is no immediate prospect of success.

The recommended methods of avoiding facial eczema, by turning sheep on to turnips and such crops, or by feeding hay or silage to sheep concentrated in small paddocks during danger periods, are working for the reason that there is no appreciable amount of the fungus in these feeds.

There are glimmerings that some types of pasture are more favourable to the fungus than others. It may be possible to develop ways of managing pastures that discourage build-up of *Pithomyces chartarum*, but these methods will take time to develop.

By and large, a desirable conclusion to the work on facial eczema is still some way off. If fortune should smile, and the work for a vaccine prosper, the problem may be solved in one blow. On the other hand, if, in the end, control of the fungus is to be the key to control of facial eczema, some changes in farm management will have to be undertaken. Work to this end is unlikely to be spectacular, and will involve careful study of wider problems than facial eczema.

DISCUSSION

Q:: *Where is the fungus usually found in a pasture?*

A:: The fungus grows and produces spores only on dead plant material. It usually grows on debris that is sheltered and kept moist by a cover of living pasture plants, but during damp weather it can grow on exposed dead plant matter. Spores when ripe are blown off their parent hyphae by winds, and great numbers of them can be found adhering to, though not growing on, living grass leaves at all levels in a pasture.

Q:: *Are there any fungicides at present available which will control* Pithomyces chartarum *and, if so, are they toxic to animals?*

A:: There are several chemical fungicides which either can kill the fungus after it has begun to grow, or can prevent its spores from germinating and establishing new growth. Some of these would be harmless to animals. But none of the fungicides examined to date could be used by a practical farmer in an economical fashion.

Q:: *Would Dr Brook comment on the optimum temperature for growth of the fungus in the field?*

A:: The optimum temperature is the same in the field as in the laboratory, somewhere in the upper seventies Fahrenheit. Periods of only several hours each day at optimum temperatures, though not as favourable as continuous optimum warmth, still promote vigorous growth of the fungus.

It should be emphasized that the temperatures affecting *P. chartarum* in the field are the temperatures of the microclimate in amongst the pasture plants. These temperatures are not recorded by standard meteorological stations. We can only infer from such measurements as are made, like grass minima, screen maxima, 4 in. soil temperatures, and so on, what kind of temperatures are being experienced within the pasture microclimate.

Q:: *Are the climatic conditions which produce mushrooms in the autumn similar to those which promote growth of* Pithomyces chartarum *and an outbreak of facial eczema?*

A:: Yes. *Pithomyces chartarum* and the mushroom are similar in requiring damp weather for optimum growth. The temperature optimum for the mushroom, though, is rather lower than that for *P. chartarum.* This means, I suppose, that one would expect to see mushrooms towards the latter part of the high-growth period of *P. chartarum,* when temperatures were falling, rather than simultaneously with the onset of peak growth of *P. chartarum.* Since visible symptoms of facial eczema do not usually show up until some time after the animal has eaten a toxic dose of the fungus, mushrooms could be appearing at about the same time as a facial eczema outbreak was showing up on animals in the field.

Q:: *Does the dead material which accumulates as a result of rust on ryegrass aid the growth of* Pithomyces chartarum*?*

A:: Yes. Heightened development of *P. chartarum* following rust infection is particularly noticeable in ungrazed ryegrass pastures in autumn, where lying-over long green leaves can shelter a large amount of dead leaf matter, keeping it in a moist condition.

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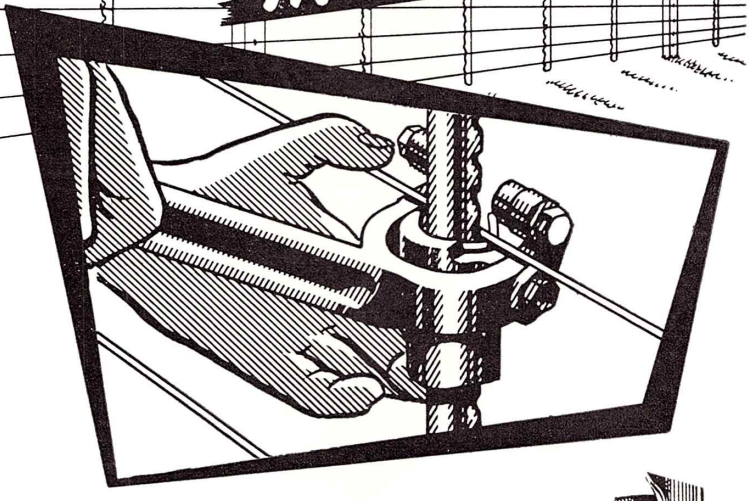

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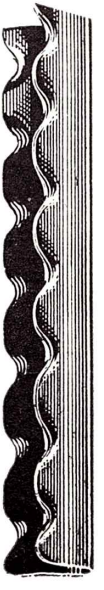

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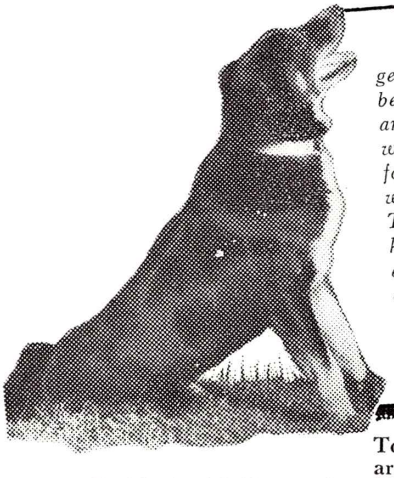

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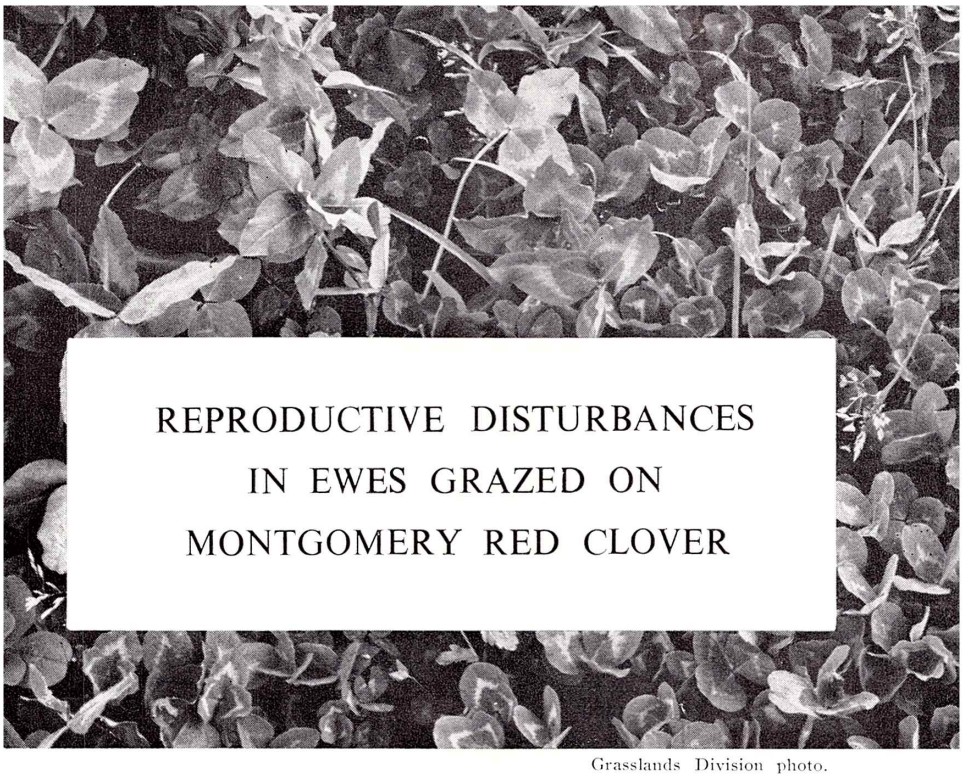

REPRODUCTIVE DISTURBANCES IN EWES GRAZED ON MONTGOMERY RED CLOVER

Grasslands Division photo.

T. S. CH'ANG*

MONTGOMERY RED CLOVER is frequently present in pastures grazed by sheep in New Zealand. It is included in the pasture seeds mixture because it can provide a large quantity of food during the late summer and early autumn when other pasture species are relatively less productive. It is known that red clover contains oestrogenic substances which, in certain circumstances, can cause reproductive disorders in sheep. For instance, in an earlier study, Romney ewe lambs, when grazed on pastures predominantly Montgomery red clover in content, showed abnormal breeding behaviour and, accordingly, further investigations were undertaken using aged ewes.

The present paper reports an experiment carried out in 1959 and repeated in 1960 at Massey Agricultural College, Palmerston North. The experiment was designed to provide a comparison of the reproductive performance of two groups of Romney $5\frac{1}{2}$-year-old ewes, one of which was grazed on Montgomery red clover (red clover group) and the other on pastures consisting of ryegrasses and white clover (control group).

**Massey Agricultural College, Palmerston North.*

Description of Experiment

During the spring of 1958, an area was sown with Montgomery red clover (late flowering variety). This clover established well and was grazed by the red clover group in 1959 and 1960. The control group grazed pastures of a type normally available to sheep on the College farm. Samples of red clover were tested by feeding to mice and found to be oestrogenic during all periods of utilization.

Each year an even line of Romney 5½-year-old ewes was divided at random into two groups and the red clover group was grazed continuously on red clover from January to the beginning of May. Subsequent to the red clover grazing period, both groups were run as one mob on the ryegrass and white clover swards.

Each year ewes in both groups were joined with rams in March and April. In the 1960 mating season, precautions were taken to randomize the fertility of the rams between the red clover and the control ewes. This was achieved by using in rotation three rams between these two groups of ewes. At lambing, detailed data on the performance of each ewe were collected.

Results

The average date of lambing of the ewes in the red clover and the control group is shown in Table 1.

It can be seen that the red clover ewes lambed later than the control ewes to the extent of 17 days and six days in 1959 and 1960 respectively.

The average lambing percentage of the ewes in both groups is shown in Table 2.

There is little doubt that the ewes grazed on red clover were less fertile than the control ewes.

TABLE 1: Average Date of Lambing

	*No.**	*1959*	*No.**	*1960*
Red clover	13	10/9	15	17/8
Control	18	24/8	17	11/8
Difference (days)		17		6

*Includes only those ewes which lambed.

TABLE 2: Average Lambing per cent., 1959 and 1960

	No. of ewes	*At birth** (%)	*One day later†* (%)
Red clover	42	86	71
Control	41	139	122
Difference		53	51

*Based on all lambs born (dead or alive) at birth and ewes (excluding deaths) put to the ram.
†Based on live lambs only one day after birth and ewes (excluding deaths) put to the ram.

Discussion

It has been shown that reproductive disturbances were associated with the ewes grazed on red clovers. These disturbances consisted of late lambs and lower lambing percentage. No other abnormalities, however, were found in the ewes grazed on red clover. The present findings do not necessarily imply that Montgomery red clover as a component of sheep pastures will have adverse effects on ewes under normal farming conditions. It should be emphasized that Montgomery red clover used in the present study was practically a pure stand and a prolonged period of clover grazing (four months) was chosen deliberately, in order to demonstrate the existence, or otherwise, of a "red clover problem".

It is suspected that ingestion of oestrogenic red clover in the present study had produced an unfavourable condition within the ewe, for the process of fertilization or implantation of the fertilized egg. Failure in either of these two phases of reproduction could result in the observed disturbances in the Romney 5½-year-old ewes grazed on oestrogenic Montgomery red clover.

Acknowledgements

The author wishes to record the co-operation of W. R. R. Hewitt and generous assistance of A. Don and his farm staff. Technical assistance was given by B. Thatcher and R. Gunn. Plant dissection was done by the Herbage Analysis Laboratory, Grasslands Division, D.S.I.R., and freeze-drying of the red clover samples for small animal tests was done by Plant Chemistry Division, D.S.I.R. To each and everyone concerned, the author is grateful. The assistance and counsel of Dr D. S. Flux in several phases of this work were invaluable.

DISCUSSION

Q:: *Why was red clover chosen for this study?*

A:: Montgomery red clover was chosen for this work because, in an earlier study, it was found that there were reproductive disturbances in Romney ewe lambs grazed on this variety of red clover.

Q:: *On the basis of these results, should red clover be used as a sheep feed?*

A:: It is too early to say that red clover should not be fed to ewes. Further experimentation is required to provide an answer to this question.

Q:: *Has red clover any effect on the fertility of rams?*

A:: No effect was observed in this experiment. Prolonged red clover grazing may affect the fertility of rams.

Q:: *Should ewe lambs be grazed on red clover?*

A:: In a separate study, it was found that ewe lambs eating red clover did not have lowered fertility when they lambed as two-tooth ewes.

Q:: *Does cowgrass also have the same effect as Montgomery red clover?*

A:: Cowgrass was not used in this experiment. Cowgrasses, however, have been found to be oestrogenic as was Montgomery red clover.

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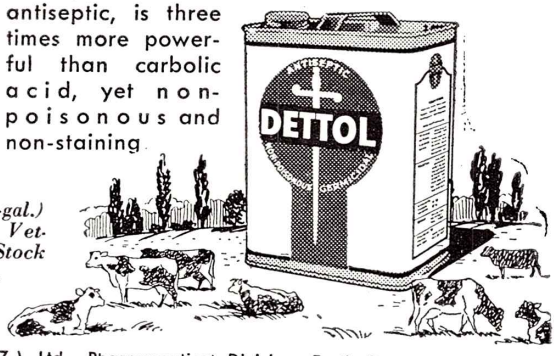

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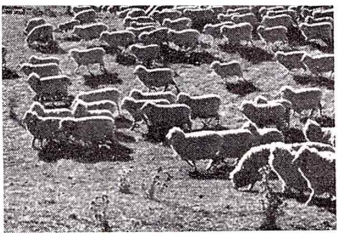

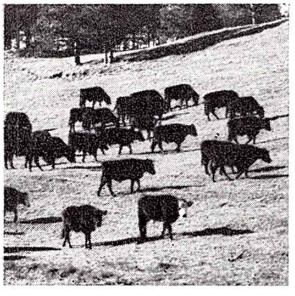

SURVEY WORK IN SHEEP AND BEEF CATTLE IN NEW ZEALAND

I. M. CAIRNEY*

THE New Zealand Sheep and Beef Cattle Survey was established by the Meat and Wool Boards to survey problems of disease, breeding, feeding and management which are important to the sheep and beef cattle industries.

In this paper it is proposed to outline what is being done by the organization and to describe also survey work which has been carried out previously in New Zealand and what has resulted from it. This will also serve to show the methods and approach used in survey work.

Surveys and Why They are Carried Out

In general, surveys are designed to determine the true nature of something by means of measurement of the various components of it. For instance, sheep fertility surveys show the particular contributing factors which go to make up lambing percentages—*e.g.*, percentages of ewes with twins, with singles, barren ewes and lamb deaths. A survey of this kind should also go deeper than this, and show, for example, the main reasons for barrenness in ewes, for lamb deaths, and the extent to which each of these factors influences the percentages.

Such information on the main causes of loss and inefficiency in animal production is valuable in two ways. It shows aspects where further research is required and it frequently demonstrates the most efficient management practices.

**New Zealand Meat and Wool Boards' Sheep and Beef Cattle Survey, Box 248, Wellington.*

The elimination of sources of loss in animal production is unquestionably of great importance when production costs continue to be at a high level while returns are lower.

New Zealand Surveys

Surveys carried out for the Gisborne Veterinary Club, by McFarlane and others, have shown the economic importance of epididymitis in rams, abortion in ewes, and deaths of lambs between birth and marking. Knowledge of the extent of these losses has stimulated research by Buddle, Hartley and other workers at Wallaceville Animal Research Station, which has resulted in the development of a vaccine to protect rams against epididymitis. It has also greatly increased knowledge of such diseases as toxoplasmosis, brucellosis, vibriosis and white muscle disease, which are responsible for a substantial loss of lambs.

New Zealand Sheep and Beef Cattle Survey Projects

The field work for the various projects is carried out for the survey by veterinary clubs in different areas, and payment is made to them for this work. For most of the surveys it is necessary to work with randomly selected farms to give a good cross-section of farming in the district concerned.

At present the survey is working with groups of about 20 farms in each of the Gisborne, Waipukurau, Ashburton, Balclutha and Edendale areas. It is the aim to add to these groups so that a number of other important stock raising areas are represented.

Sheep fertility is obviously of the greatest importance in the efficiency and the profitability of sheep farming and consequently has been given pride of place in the work of the Survey.

The results of an examination of the official lambing percentages for different districts (Fig. 1) give an idea of the position.

There are no evident explanations for many of the differences and variations in some of the district figures.

As a step towards a better understanding of the situation, certain important basic information is being collected from as many farms as possible. This includes such percentages as lambing percentage (lambs docked per hundred ewes bred), barren ewes, ewe deaths, lamb deaths, abortions, ewes with twins and ewes with singles.

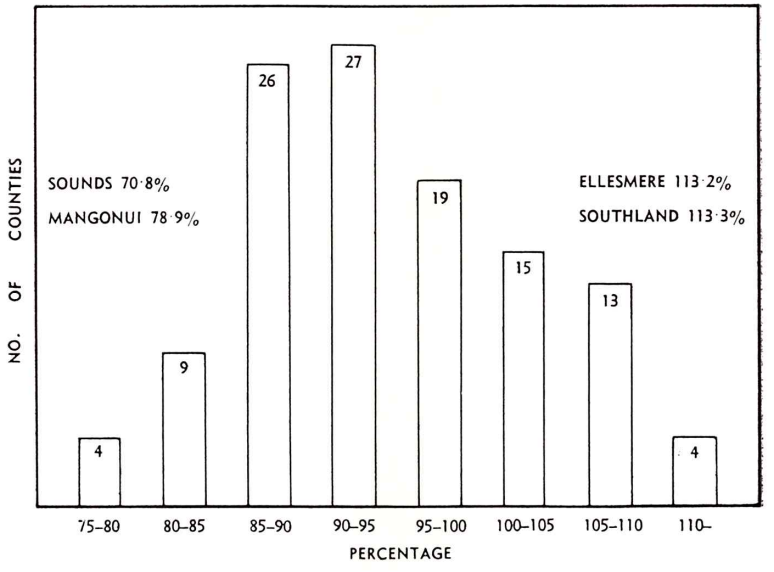

Fig. 1: Distribution of counties by lambing percentage.

The information available does show where the main losses occur and indicates aspects requiring closer investigation. This is shown by figures for a number of North Island farms.

Figure 2 shows, at top, the average percentages for 20 North Island hill country farms of dead ewes, dry-dry ewes (*i.e.*, ewes which at lambing time show no evidence of having been in lamb), no lamb ewes (ewes which have lost all lambs born to them) and foster ewes. These averages are shown for comparison with the figures for four individual farms.

The figures for Farm 1 show the importance of good shepherding —efficient fostering. Farm 4 clearly shows the importance of twinning in achieving a satisfactory lambing percentage even when dry-dry ewes and lamb deaths are quite high. Further aspects of the sheep fertility situation are shown by an analysis of figures for 18 years from a North Island property carried out by W. B. Taylor, Statistician, New Zealand Sheep and Beef Cattle Survey (Fig. 3).

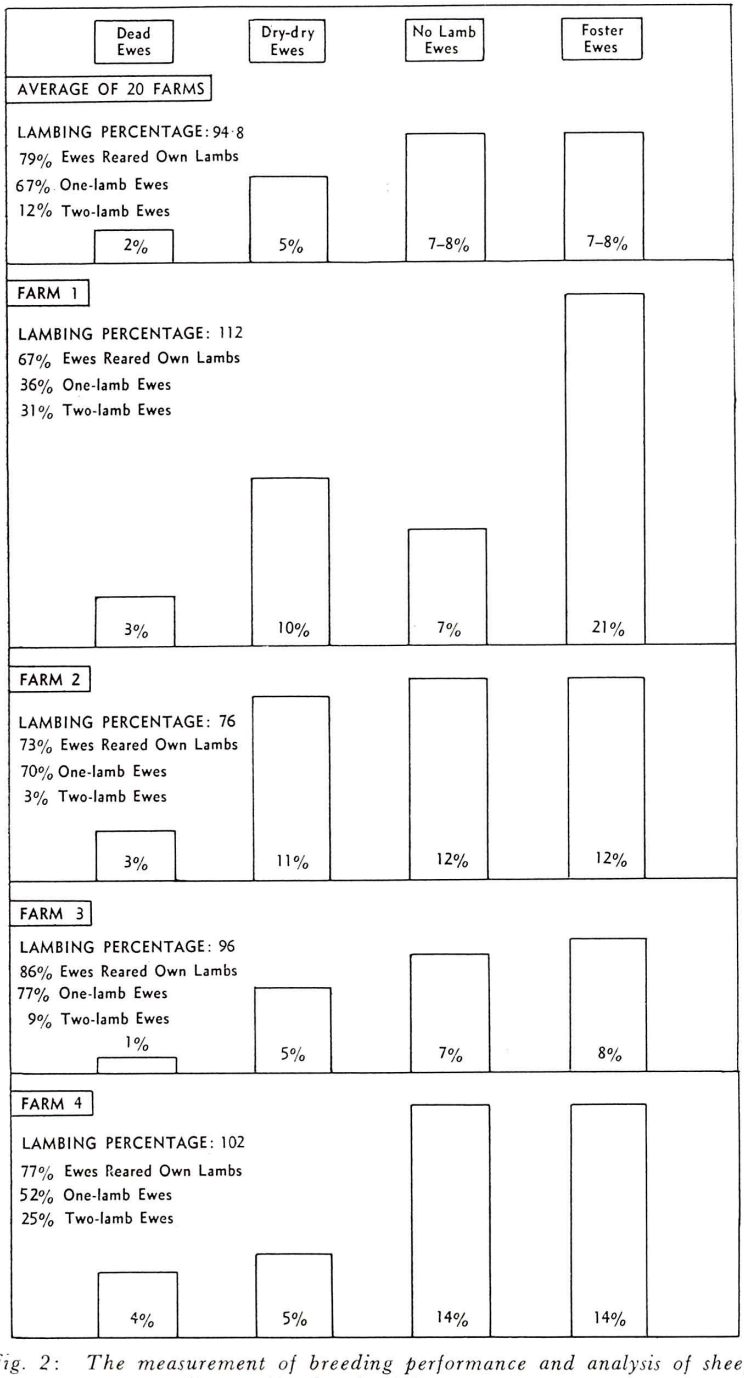

Fig. 2: The measurement of breeding performance and analysis of sheep fertility on North Island hill country farms.

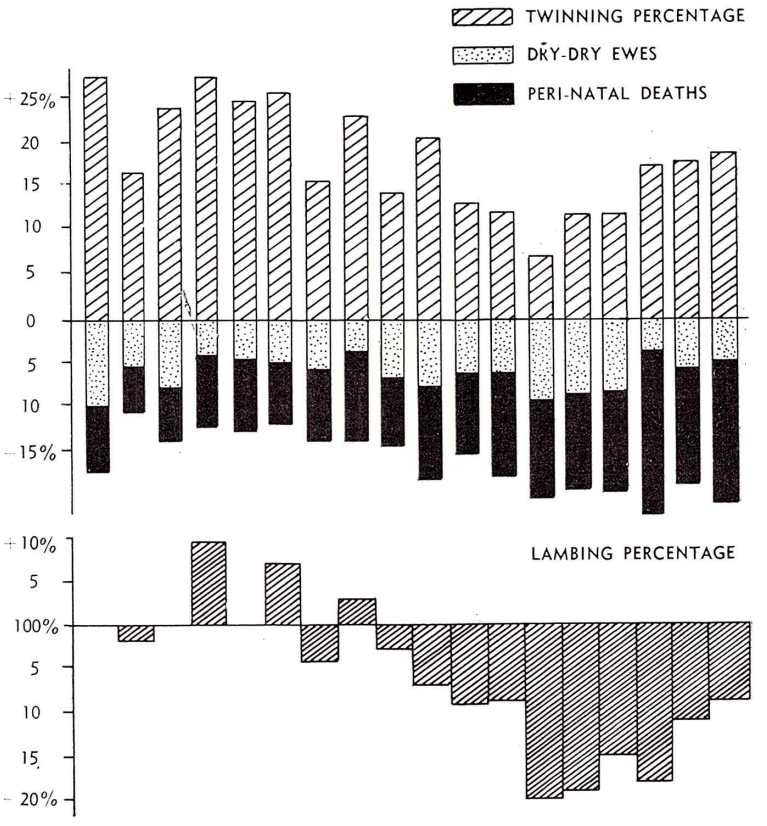

Fig 3: Variation in lambing percentage, North Island fat lamb farm, 1942-1959.

Of the total variation of lambing percentage over the 18-year period:

41 per cent. is due to the variation in the number of twins born.

20 per cent. is due to the variation in the number of dry-dry ewes from year to year.

19 per cent. is due to the variation in the number of lambs dying over the lambing period and up to one week from birth.

20 per cent. is the remainder and is due to such factors as dead ewes, weather, lamb losses other than at lambing and up to one week from birth.

The Survey would welcome hearing from any farmers who are willing to record this kind of information accurately.

It is planned to look much deeper into the causes of abortions and deaths of lambs during or immediately after birth. This entails large numbers of post-mortem and laboratory examinations of dead lambs. A method of classifying these lambs was developed by D. McFarlane when he was working in the Gisborne district. Briefly, these lambs may be classified from post-mortem findings into those which died prior to the commencement of the birth process, during, or after it. In addition, it can be determined whether they have breathed, fed, or walked, and the presence of one of the four important diseases causing losses of lambs—*i.e.*, toxoplasmosis, brucellosis, vibriosis or white muscle disease can be detected. There are still considerable gaps in knowledge of the cause of this large loss of lambs—which is, in fact, a substantial loss of national income.

Some figures from McFarlane's work in Gisborne in 1956 show the picture there at that time.

Lambs examined	3,543
Ante parturient deaths	7%
Parturient deaths	36%
Post parturient deaths	58%

6% failed to breathe
20% breathed—did not walk
36% walked—failed to feed
38% walked and fed.

McFarlane's work has also produced information on other important aspects of lamb losses—in particular difficult births, exposure, starvation and mismothering.

Difficult Lamb Births—1956

20 per cent. of 226 lambs under 5 lb.
29 per cent. of 1,804 lambs 5 to 10 lb.
69 per cent. of 1,001 lambs over 10 lb.

Exposure

799 lambs died with only part of body fat used.
94 per cent. of these showed disease lesions.
6 per cent. of these showed uncomplicated exposure.

McFarlane has suggested that exposure uncomplicated by disease may be relatively rare but that, when some disease lesions are already present, it may be of considerable importance.

STARVATION AND MIS-MOTHERING

734 lambs walked but did not feed.
31 per cent. fully used body fat.
89 per cent. of these showed disease lesions.

Not more than 3 per cent. of 3,470 lambs were uncomplicated starvation.

Not more than 0·5 per cent. of total lambs born could have been classed as uncomplicated starvation.

Again from these data it is evident that there is still much to learn about this aspect of sheep fertility.

Sheep Growth Rates

The growth rates of young sheep is of obvious importance with regard to the fattening of lambs. It is also important in regard to ill-thrift in hoggets. In addition, there is a mounting volume of evidence that the growth rate of young sheep is closely related to the fertility of two-tooth ewes—which is very low on many farms.

While there is some information about sheep growth rates on research stations there is very little known about sheep under the various farming conditions in different parts of New Zealand.

For the above reasons surveys of sheep growth rates have been started in various parts of New Zealand and it is planned to record the fertility of the groups of two-tooth ewes which are being studied.

This project has only recently commenced but already there are some interesting data. It was rather surprising to find that some two-tooth ewes lost weight during the mating period. Two-tooths in one area were no heavier immediately prior to mating than hoggets in another area much less favoured climatically.

It is the writer's belief that weighing of some young sheep would be a most useful addition to normal farm practice. In this way it is possible to determine accurately how well young sheep are doing. Eye appraisal, even by a skilled and experienced sheep man, cannot do this nearly so accurately as the scales.

Annual Stock Death Rates on Farms

Deaths of sheep and cattle are an obvious direct source of financial loss and wastage. Careful inquiry shows that there are very few farms where deaths are known accurately and it is cer-

tainly not known nationally. For this reason surveys are being carried out to determine accurately the extent of these deaths and their causes under varying conditions.

The figures from farms where records have been kept show a surprisingly high death loss.

This is demonstrated by the following figures from a well-managed Southland fat lamb farm which buys a draft of good 4-year-old ewes annually:

EWE DEATHS: July, 1957 to April, 1961

	1957/58	*1958/59*	*1959/60*	*1960/61*	*1957-60*
Ewes carried	1,121	1,148	1,163	1,150	Percentage
			LOSSES		
July	6	0	5	8	4·3
August	15	19	13	19	18·7
September	13	20	27	11	23·8
October	7	8	11	17	10·3
November	7	7	8	11	8·7
December	15	6	6	4	10·7
January	1	0	4	1	2·0
February	2	1	3	0	2·4
March	4	6	9	1	7·5
April	4	1	4	2	3·6
May	3	2	1	0	2·4
June	3	1	10	0	5·6
Total	80	71	101	74	100·0

Any farmers willing to keep accurate records of sheep or cattle losses would assist the Survey.

Beef Cattle Surveys

Owing to the relatively recent establishment of the New Zealand Sheep and Beef Cattle Survey it has not yet been possible to start a number of projects in beef herds. These will be commenced at an early date and priority will be given to surveys of fertility and growth rates of young cattle.

Hypomagnesaemia (Grass Staggers)

For some time there has been evidence that this disease frequently causes severe losses of beef breeding cows in certain North Island districts.

Preliminary surveys have been carried out in the Poverty Bay, Waipukurau and Bay of Plenty areas with the assistance of the local veterinary clubs and in the Hastings area with the assistance of Federated Farmers.

Complete information is not yet available from this work.

I wish to express appreciation to farmers in the Poverty Bay, Bay of Plenty and Hawke's Bay areas who replied to the questionnaire.

Further information would be welcomed on the incidence of this disease from anyone able to provide it.

In this paper it has been the aim to present the reasons for surveys and their importance in attaining greater efficiency in the meat and wool producing industries. Success in this work depends on good co-operation from farmers and this has been freely given.

Acknowledgement

The statistical work on the figures and the histograms used in this paper were done by W. B. Taylor, Statistician, New Zealand Sheep and Beef Cattle Survey.

DISCUSSION

Q:: *Is it proposed in the stud sheep survey to include a study of the problems of genetic improvement?*

A:: The detailed plans of this survey have not yet been decided but it is intended that factors where genetic improvement plays a part in increased productivity will be given full attention.

Q:: *Have you any information on the effect of body temperature on lambing percentages?*

A:: I am unaware of any evidence on this in New Zealand. There is evidence in Australia of the depressing effect of extremely hot climatic temperatures on the breeding performance of rams.

Q:: *Has fertility any relationship to lambing time?*

A:: There is some evidence that ewes shed more eggs later in the breeding season and that matings at this time can be expected to produce more lambs. This may possibly contribute to the higher lambing percentages in the southern part of New Zealand as here rams are put out at a time which is closer to the maximum rate of egg shedding.

Q:: *Is it an advantage to select rams or ewe hoggets which are themselves twins?*

A:: Yes. It has been shown in New Zealand and overseas that a significant increase in lambing percentage has occurred in flocks where this practice has been consistently carried out.

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Symposium

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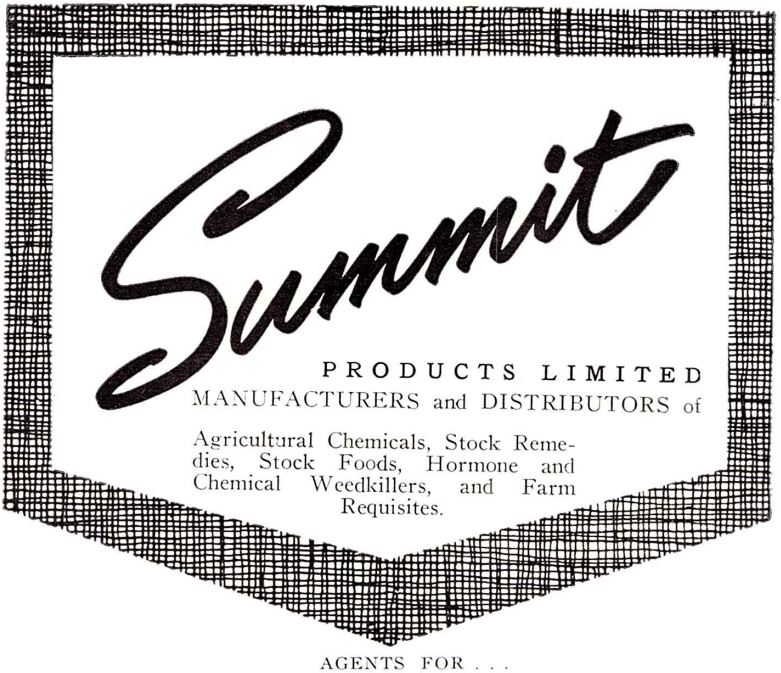
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THE EFFECTS OF
DIFFERENT PASTURE SPECIES AND VARIETIES
ON SHEEP PRODUCTION

I: LIVEWEIGHT GROWTH AND CARCASS COMPOSITION

A. L. RAE, R. A. BARTON, and M. J. ULYATT*

THE BREEDERS of pasture plants in New Zealand have been very successful in developing new strains and varieties which have improved production, both in terms of yield per acre and in the seasonal spread of this yield. While improved productivity is clearly necessary, it is not sufficient for the purposes of grassland farming. Additional requirements of an adequate pasture species, or combination of species, are that:

(1) They should be free of substances that are deleterious to the animal.

(2) They should be able to supply sufficient quantities of the minerals which are essential to the animal.

(3) The quality of the main energy-producing and protein-forming constituents should be such that high levels of animal production can be obtained.

In other words, the response of the animal to the pasture is of over-riding importance.

Throughout this symposium, frequent reference will be made to an experiment designed to investigate aspects of the relationship of pasture quality to sheep production.

Associated with the authors in various aspects of this work are Dr A. T. Johns, Dr G. W. Butler and Dr R. W. Bailey (Plant Chemistry Division), R. W. Brougham (Grasslands Division) and Dr D. S. Flux (Massey College).

The main objective of the experiment has been to compare perennial and short-rotation ryegrass singly and with white clover, from the viewpoint of their effects on the iodine nutrition of sheep. As an integral part of this experiment, a study was made of the growth and carcass composition of the animals grazing these different pastures, and this is the subject of the present paper.

**Massey Agricultural College, Palmerston North.*

Experimental Layout

The work to be reported consists of two trials, one covering the period 1957-58 and the other 1959-60. They will be referred to, respectively, as Trial I and Trial II. In both trials, the pastures compared were:

(1) Perennial ryegrass alone (P).

(2) Short-rotation ryegrass alone (S).

(3) Perennial ryegrass and white clover (P + C).

(4) Short-rotation ryegrass and white clover (S + C).

Trial I

In this trial, two paddocks of the Massey College sheep farm were used. The first, paddock 16, was subdivided into eight plots, each of approximately one acre in size. Half of these plots were sown with perennial ryegrass and half with short-rotation ryegrass. (For the detailed layout see 1957 *Sheepfarming Annual*, p. 182.) The second area, paddock 30, of approximately five acres, was divided into four plots, two of which were sown to perennial ryegrass and white clover, and the other two with short-rotation ryegrass and white clover. The pastures were sown in November, 1956, and were topdressed with superphosphate and lime. The pure grass swards in paddock 16 were also topdressed, as required, with sulphate of ammonia.

On May 10, 1957, ewe hoggets were put on all plots, the stocking rate being about ten to the acre. Body weights of these hoggets were taken at approximately monthly intervals from the start of the experiment. Half of the sheep on each plot were injected intramuscularly with 1 ml of iodinated poppyseed oil containing 40 per cent. iodine. A second injection was given on February 27, 1958. The action of the iodinated poppyseed oil is to form a depot which gives a continuous release of iodine into the bloodstream. Comparison of the injected and non-injected sheep within each pasture group showed that the iodine treatment had no appreciable effect on growth rate. Consequently, the iodine treatment has been ignored in the comparison of growth rate on the different pastures.

The objective in the management of the stock on the various pasture areas was to ensure that sufficient pasture was available at all times so that growth rate was not limited by pasture scarcity. This was achieved by adjusting the stocking rate in each plot to

the feed available. When the stocking rate was found to be too high, experimental sheep were removed at random from the plots. When it was found necessary to control excess pasture growth, extra sheep were brought on to the area but were not included as experimental animals. Because of facial eczema, infestation of the short-rotation pastures by Argentine stem weevil, and other difficulties, it was not possible to maintain the objective of adequate quantities of pasture over the whole of the experimental period. Consequently, the growth in body weight of the sheep in this trial is considered only over the period from May 10, 1957, to December 3, 1957. In this period, it is believed by those concerned with the trial that, with one exception to be mentioned later, shortage of pasture was unlikely to have limited the growth rate of the animals.

Rams were put with the ewes on March 25, 1958, and were rotated around the groups of ewes on each plot so that fertility differences between rams would not affect comparisons between treatments. All lambs were weaned on December 4, 1958, and the ewes were slaughtered a fortnight later in order to obtain their thyroid glands for study.

Trial II

The second trial was again primarily concerned with investigation of the effects of the pasture types on the iodine status of the sheep. An important change, however, was made in the lay-out of the area. In Trial I, the two paddocks involved, numbers 16 and 30, were separated by about half-a-mile. As this distance could possibly have introduced unidentified differences between the all-grass and the grass-plus-clover pastures, it was decided to include in the experiment paddock 17 which adjoins paddock 16. This new paddock was fenced so that the gully passing through it was excluded from the experimental area and the remainder divided into four plots, each of about $1\frac{1}{2}$ acres. At the same time, the four pasture types were re-allocated to the 12 plots available to give the lay-out shown in Fig. 1.

On July 16, 1959, ewe hoggets were allocated at random to the 12 plots. As in the previous trial, half the lambs in each pasture group were given an intramuscular injection of iodinated poppyseed oil, and again it was found that this had no appreciable effect on growth rate. The sheep were weighed at approximately monthly intervals and the general objectives in management were the same as in the previous trial. In the second trial, no difficulties arose until January when, in spite of the use of DDT, one of the short-

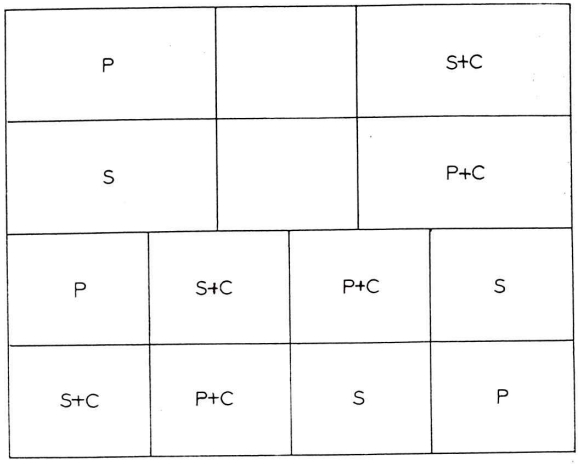

Fig. 1: Layout of experimental pasture plots in paddocks Nos 16 and 17.
P = perennial ryegrass.
S = short-rotation ryegrass.
P + C = perennial ryegrass plus white clover.
S + C = short-rotation ryegrass plus white clover.

rotation plots was severely infested with Argentine stem weevil. Consequently, the comparison of the growth rate of the sheep is confined to the period July 16 to December 31, 1959.

As in the previous trial, the ewes were mated with Romney rams. In December, all ewes were slaughtered to obtain their thyroid glands. A random sample of eight ewes which had produced and reared single lambs was taken from each pasture group for detailed study of their body composition and internal organs.

Growth of the Experimental Sheep

The average growth curves for the hoggets on each pasture type are presented for the two trials in Figs. 2 and 3.

In Trial I (Fig. 2) it is seen that the growth curves soon became separated. By early July, the S + C group was significantly heavier than the P and the S groups. At the end of the period on December 3, the S, P and S + C groups were all significantly different in weight. In this connection, the P + C group requires special mention. The establishment of white clover in both plots of this treatment was unsatisfactory and, in the spring of 1957, this poor clover growth resulted in the perennial ryegrass becoming stunted and unpalatable. This was reflected in the slow growth of the hoggets grazing this pasture. Consequently, it is not valid, in this case, to compare the P + C group with the other groups after August.

In Trial II (Fig. 3), the growth curves of the groups were similar to those found in Trial I, with the exception of the P + C group. In this trial, however, there was no problem of clover establishment and consequently, a truer assessment of the growth of hoggets in the P + C group was obtained.

It is of interest to note the effect of the different pastures on the weight of the ewes prior to mating, as found in Trial II. It must be noted that the ewes had been confined on two occasions, for a total of 18 days, as a precaution against facial eczema. Also, because of the failure of one plot of short-rotation ryegrass as a result of infestation with Argentine stem weevil, it is likely that there was some limitation in the amount of pasture available to this group. Nevertheless, prior to mating, the S + C group

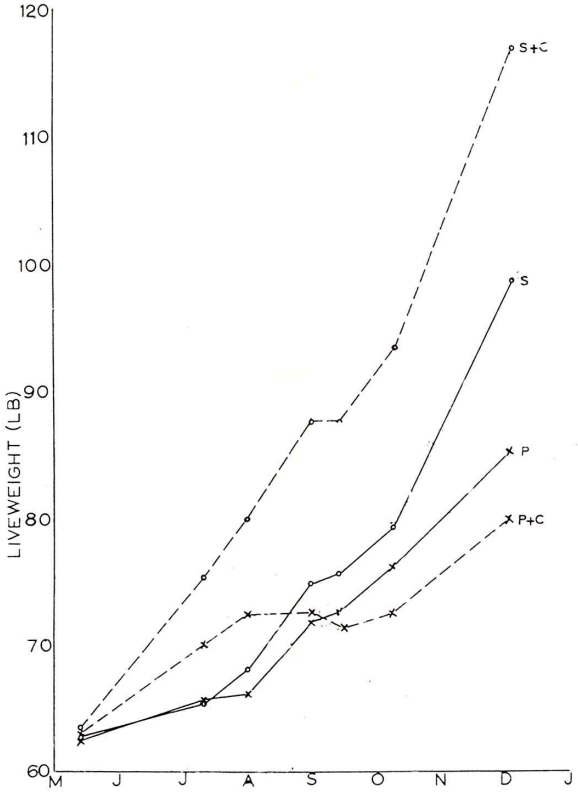

Fig. 2: Liveweight changes of the sheep on the four pastures. Trial I, 1957–58.

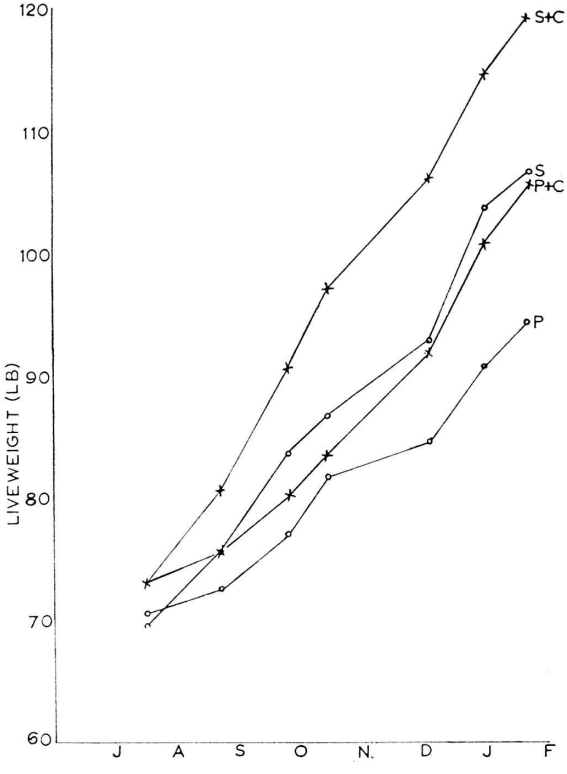

Fig. 3: Liveweight changes of the sheep on the four pastures. Trial II, 1959–60.

averaged 25 lb heavier than the P group, the other two groups being near the same weight and mid-way between the two extremes.

Carcass Weight and Carcass Composition

In Table 1 averages for carcass weight and the weights of water, fat, protein and ash, for Trials I and II, are given. It will be noted that the average carcass weight of the ewes from the P group is the lowest of all while the S + C group at the other extreme has the highest average. The difference was 25 lb in the first and 28 lb in the second trial in favour of the carcasses from the short-rotation plus white clover plots.

The composition of the carcasses in terms of the weights of water, fat, protein and ash, in general follow the group averages shown for carcass weight. Thus, the group with the lightest car-

TABLE 1: Carcass Data—Trial I and Trial II

	Perennial Ryegrass (P)	*Perennial Ryegrass plus Clover (P + C)*	*Short-rotation Ryegrass (S)*	*Short-rotation Ryegrass plus Clover (S + C)*
		TRIAL I		
Liveweight (lb)	103	119	128	138
Frozen carcass wt (lb)	56·2	70·2	74·7	81·5
Water wt (lb)	22·9	26·1	28·1	29·7
Fat wt (lb)	25·5	35·4	36·8	40·6
Ash wt (lb)	2·0	2·3	2·5	2·6
Protein wt (lb)	6·5	7·4	8·0	8·6
		TRIAL II		
Liveweight (lb)	97	125	120	137
Frozen carcass wt (lb)	40·9	59·1	61·2	69·1
Water wt (lb)	21·5	27·8	26·3	31·4
Fat wt (lb)	11·3	21·2	25·0	26·1
Ash wt (lb)	1·7	2·5	2·3	2·5
Protein wt (lb)	6·4	7·6	7·6	9·1

cass weights also has the lightest weights of the four major components of the carcass. There are a few exceptions to this general relationship seen in the P + C and S groups in Trial II but no explanation for these can be given from these data.

Conclusion

Summarizing both trials, it is clear that the pastures investigated have produced markedly different rates of growth of the animals grazing them and that these differences were established soon after the animals were put on the different pastures. The differences in rates of growth contain two major effects:

(a) An effect due to the difference between the perennial and short-rotation ryegrasses. In the second trial this effect resulted in a difference of 15 lb in average liveweight at December 31, 1959.

(b) An effect which can be attributed to the presence of white clover. In Trial II, white clover produced a difference of 9 to 10 lb in average liveweight of the sheep at December 31, 1959.

The evidence which is available from the experiment to explain these differences will be covered by Dr A. T. Johns in Part III of this symposium.

THE EFFECTS OF
DIFFERENT PASTURE SPECIES AND VARIETIES
ON SHEEP PRODUCTION

II: DIFFERENCES IN GOITROGEN AND IODINE INTAKE

D. S. FLUX*

THE EXPERIMENT, as explained in Part I of this symposium, was designed to investigate whether the goitrogenic effect of white clover would cause a reduction in thyroid gland activity large enough to lower the productive performance of sheep grazing pastures containing ryegrasses and white clover. Deficiencies in iodine uptake by the thyroid, because of low availability of iodine in the pasture, or because of the presence of a goitrogen in clover and ryegrass, would be expected to be reflected in differences in the thyroid weights of the animals, whether or not the deficiencies were sufficiently severe to affect such things as liveweight growth. A goitrogen is a substance which inhibits the formation of thyroid hormone.

In Trial I, the effect of the clover goitrogen was clearly shown by the increased thyroid weights of the sheep not injected with a depot of iodine, which were grazed on either short-rotation or perennial ryegrass with clover, over those of the injected sheep grazing the same pastures. There was also a strong suggestion of a goitrogenic effect in the sheep grazed on perennial ryegrass.

In Trial II, the thyroid gland weights of the ewes treated with iodine were a little higher than the corresponding ones in the first trial, probably because they were given only one injection of depot iodine instead of two. However, they were lower than those of the non-injected sheep on the same pasture, except in the case of short-rotation ryegrass and clover where there was very little difference. No effect ascribable to clover was seen in these ewes, the thyroids of the non-injected sheep grazed on the ryegrasses alone being of much the same size as those of the non-injected sheep grazed on the clover-containing pastures. It seems that the pure ryegrass pastures were somewhat goitrogenic, as were those containing clover.

**Massey Agricultural College, Palmerston North.*

In Trial I the enlargement of the thyroids of the lambs appeared to be due to the white clover grazed by them. Iodine in milk of the injected ewes prevented this effect of clover, except in the case of the lambs of the ewes on perennial ryegrass and clover; these lambs had to be kept on pasture for a longer period after weaning than those of the ewes on short-rotation ryegrass and clover.

In the second trial, there may have been a slight effect of clover, but the outstanding result was the great enlargement of the thyroids of the lambs of the non-injected ewes grazed on short-rotation ryegrass. This did not occur in the first trial.

Guinea-pigs were fed ryegrasses from the pastures the sheep grazed in the second trial, and it was shown by M. J. Ulyatt that both ryegrasses caused thyroid gland enlargement if fed alone at high levels, but no enlargement occurred if the amount of these ryegrasses eaten was restricted.

In summary, the situation seems to be that eating either of the ryegrasses or white clover can lead to thyroid enlargement. Because this can be overcome by treating the sheep with iodine, it is probably caused by iodine deficiency in the diet and/or goitrogens of the thiocyanate type which reduce the uptake of iodine from the digestive tract by the blood and by the thyroid gland from the blood.

The degree of thyroid enlargement seen was not associated with a depression in the productive performance of the sheep sufficiently great to be detected in these trials. Much more spectacular cases of thyroid enlargement do occur sporadically in animals grazing pasture in this district, so that the possibility of depressed productive performance because of lowered iodine or increased goitrogen intake cannot be dismissed.

Work by M. J. Ulyatt and the writer is continuing on the two ryegrasses, using guinea-pigs as test animals, in the hope that it will be possible to discover what it is in these grasses that sometimes causes thyroid enlargement in sheep.

THE EFFECTS OF
DIFFERENT PASTURE SPECIES AND VARIETIES
ON SHEEP PRODUCTION

III: THE INFLUENCE OF THE FERMENTATION IN THE RUMEN ON INTAKE AND PRODUCTION IN SHEEP

A. T. JOHNS*

ONE OF THE MOST STRIKING SIGHTS seen on a recent visit to the U.S.A. was an experiment at Beltsville, the U.S. Department of Agriculture's Research Center, Maryland. One group of sheep had access to chopped lucerne hay only and the other group ate the same hay ground finely and pelleted. The former animals looked normal, well-grown sheep, while the latter appeared more like barrels on legs—*i.e.*, they were extremely fat. Research work on pelleting of roughages in the U.S.A. is very active at present.

The effect of finely grinding hay and pelleting is illustrated by two experiments:

(1) With a diet consisting of coarsely chopped hay, ground corn and linseed oil meal, eight steers gained an average of 2·05 lb per day for 56 days. Another eight received the same weight of food but the hay was ground and pelleted. This group gained 2·55 lb daily. The food intake of this second group per 100 lb gain in weight was 330 lb dry matter whereas it was 399 lb for the animals on unground hay. The grinding not only gave an increase in weight gain but it also brought about a more efficient utilization of the food.

(2) In a Californian experiment with pelleted lucerne hay and long hay fed to lambs, pelleting the hay resulted in an increase in intake from 2·8 lb to 3·59 lb per day with weight gains of 0·24 and 0·38 lb per day respectively.

In general, pelleting of hay results in both an increase in intake and efficiency of utilization for growth over that of the unground forage. In order to understand why this is so, it is necessary to consider briefly the digestive processes peculiar to the ruminant.

**Plant Chemistry Division, D.S.I.R., Palmerston North.*

Digestion in the Ruminant Animal

The stomach of sheep and cattle is divided into four compartments, the first two of which form a large fermentation vat, where conditions are ideal for microbial digestion of the food. Any forage will supply the cow or sheep with carbohydrates, ranging from the simplest sugars to the complex fibrous celluloses. These are broken down by the micro-organisms to the same limited end products, although at rates which differ greatly with different carbohydrates. The result is a mixture of volatile fatty acids—acetic, propionic and butyric—with perhaps some lactic acid. Water, carbon dioxide and methane are also produced during the fermentation.

With a diet of hay, which is relatively high in fibrous cellulose, the mixture of acids found in the rumen usually consists approximately of acetic 70 per cent.; propionic 17 per cent.; butyric 10 per cent.; and traces of higher acids, 3 per cent. When the diet is rich in soluble sugars or starch, the proportion of acetic falls and that of propionic rises. In an extreme diet—*e.g.,* a cow receiving 2 lb hay and 24 lb concentrates—the proportions may be 41 per cent. acetic and 39 per cent. propionic. With a diet consisting entirely of hay, the production of acids by fermentation is relatively slow and regular, so that there is little rise and fall over the day in their concentration in the rumen contents. With increasing amounts of soluble carbohydrates, such as in concentrate feeding, the acids tend to be produced more rapidly, giving a peak 2 to 4 hours after feeding, followed by a pronounced fall.

A unique feature of the ruminant stomach, as opposed to the simple stomach of man or dog, is that direct absorption into the bloodstream of the products of digestion occurs to a significant extent. This absorption is facilitated by the inner surface of the rumen being covered with papillae (small finger-like projections as seen on tripe). It had been thought that the development of these papillae was the result of the physical nature of the food itself because they are absent when the young animal is living on milk and develop when solid food is being eaten. It has now been shown that the chemical products of digestion—the volatile fatty acids—exert a much greater stimulating effect on the appearance of the papillae than does the physical form of the food itself. In fact, differences in the level and proportions of these acids resulting from different types of feed can have a marked influence on the extent of papillary development. The size of the rumen appears to depend on the physical nature of the food and this will be considered later. The points outlined so far can be summarized by

saying that the nature of the food that the animal eats can determine:

(1) The percentage of the volatile fatty acids formed in the forestomach.

(2) The rate of digestion.

(3) The type of development that occurs in the absorbing surface, that is, the papillae in the animal's stomach.

Utilization of Products of Fermentation in the Rumen

The implications of being able to vary these acids by feeding different foods can now be considered. Work in the last few years has shown that acetate is used by the animal in the production of fat, and particularly milk fat, by the dairy cow. It is now fully established that diets which bring about a fall in acetate and an increase in propionate in the rumen (*i.e.*, diets low in roughage) can cause a fall in milk fat production and in severe cases this can fall to a test of 1 per cent. fat). Infusion of acetate into the rumen can experimentally counteract this change whereas propionate will not.

Propionate is concerned with carbohydrate and protein synthesis. Propionate given to a dairy cow raises the solids-not-fat content, which is mainly represented by an increase in protein.

The three volatile fatty acids, acetic, propionic, and butyric, which are the major sources of energy for the ruminant, are used with equal efficiency of 85 per cent. when they meet the energy needs for maintenance.

When they are used as a source of energy for fat synthesis in the fattening animal, acetic is used with an efficiency of 33 per cent., propionic 55 per cent. and butyric 62 per cent.

Greater weight gains have been obtained in growing animals where diets have been manipulated to produce a fermentation which gives a relatively higher proportion of propionic acid.

It was mentioned earlier that this can be done by feeding a diet relatively high in soluble sugars and low in fibre. It can also be achieved by finely grinding hay. This process, as stated earlier, is being widely employed in the U.S.A. where the ground hay is made into pellets. The rumen bacteria can more easily ferment the finely divided fibre than they can ferment the unground hay.

Fig. 1: Pieces of the lining of the fore-stomachs of sheep fed on four different pastures, illustrating differences in papillary development.

The result is that, not only is there an increase in the rate of digestion of ground hay, but the proportion of propionic acid is increased.

Appetite

The increase in appetite with pelleting introduces the subject of those factors that regulate the intake of food by sheep. It is necessary to go back and consider the mode of digestion in the ruminant which allows the animal to make use of the fibrous part of the plant by microbial fermentation. The stomach is an organ in which the food is constantly stirred and the larger plant particles are regurgitated to be rechewed by the animals. As the food is

digested and broken down into a finely divided state, it passes on to the third and fourth compartments of the stomach. Hence, the more rapidly the food is digested, the more rapidly it passes on down the digestive tract. Rapidly digested concentrates and finely ground hay pass on more rapidly than long fibrous hay. With the passage of the food the animal has the desire to eat more.

The generalization is now becoming apparent that the ruminant eats more of high quality diets than of low quality diets. This effect of quality of food on increasing the intake is well illustrated by the experiments of Blaxter reported to the 8th International Grassland Conference and shown in Table 1.

TABLE 1: Food Intake of Sheep Fed *ad lib.* and their Resultant Gains.

Food	*Relative Appetites*	*Relative Weight Gains*
Poor hay	100	1·0
Medium dried grass	141	7·7
Good dried grass	162	13·4

It will be seen that appetite was 62 per cent. greater for the better food whereas the weight gains showed an advantage of a 13-fold increase.

It is becoming obvious that quite small changes in the apparent digestibility of food can have considerable consequences in terms of production under *ad lib.* feeding conditions.

The regulation of food intake by ruminants is the very reverse state of affairs pertaining to other species. With poultry, rats, and humans, it appears that the intake of digestible food nutrients is the same whether high- or low-energy diets are eaten. In other words, the mono-gastric animal or bird tends to eat to a constant energy intake. With ruminants the quality of the food is the governing factor where quality is denoted by the digestibility of its energy.

As Blaxter has pointed out, if an animal eats more of one food than another, it is usual to ascribe such a difference in intake to the fact that one food is more palatable than another. "Palatable" means agreeable to the taste. The results of experiments with sheep show, in fact, that the voluntary intake of fodders was related to the digestibility and rate of passage of the foods, attributes which are hardly consistent with their "acceptability to the palate or taste". This is, of course, a very simplified concept which can be modified by both animal and plant factors.

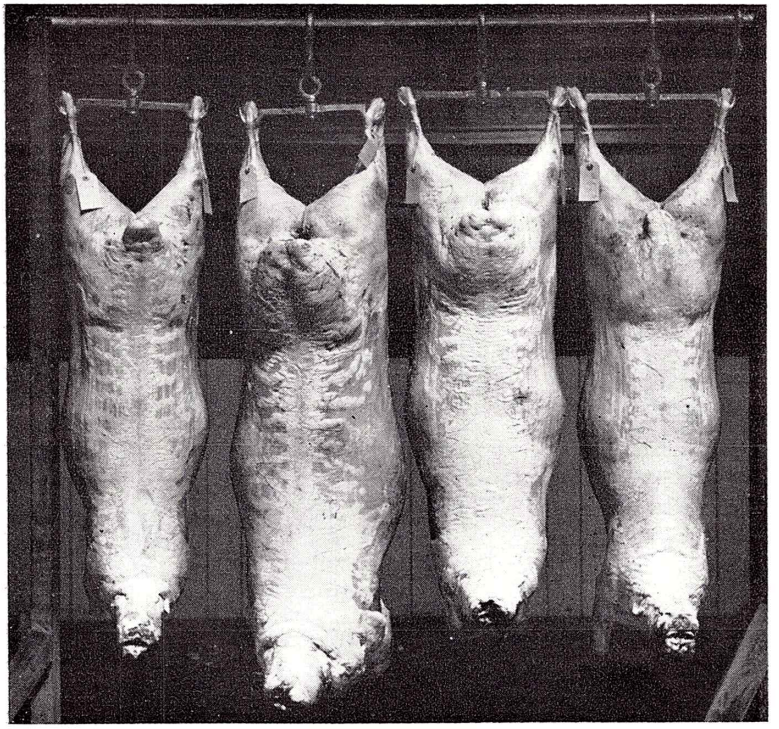

Fig. 2: Carcasses of ewes selected at random from the four different pastures. From left to right: perennial ryegrass; short-rotation ryegrass and clover; short-rotation ryegrass; perennial ryegrass and clover.

Ryegrass Strain Trial

Some data pertaining to the ryegrass strain trials outlined in Part I of this symposium are presented in Tables 2 and 3.

In the weight of rumen contents there is a highly significant difference between grasses, with the addition of clover making little difference. However, addition of clover to the diet had a significant effect on the concentration of the products of microbial digestion, the volatile fatty acids, while the difference between grasses was less marked. Hence it is seen that the animals which have grown the fastest, namely, those grazing short-rotation ryegrasses and clover, have actually the lightest rumen contents and the highest level of fermentation. Intake measurements have not been made, but from other recent work it is highly probable that

TABLE 2: Average Liveweights and Frozen Carcass Weights of Groups of Ewes fed on Four Different Types of Pasture and the Average Daily Liveweight Gain of their Lambs. Trial I (1958-59)—see p. 175 this *Annual*.

	Perennial Ryegrass (P)	*Perennial Ryegrass + White Clover (P + C)*	*Short-rotation Ryegrass (S)*	*Short-rotation Ryegrass + White Clover (S + C)*
Final liveweight ewes (lb)	103	119	128	138
Frozen carcass weight (lb)	56·2	70·2	74·7	81·5
Average daily weight gain of lambs (lb)	0·30	0·40	0·38	0·47

TABLE 3: Average Liveweights, Frozen Carcass Weights, Weights of the Rumen Contents and Volatile Fatty Acid Levels for Groups of Ewes fed on Four Different Types of Pasture for 18 months. Trial II (1959-60)—see p. 175 this *Annual*.

	Perennial Ryegrass (P)	*Perennial Ryegrass + White Clover (P + C)*	*Short-rotation Ryegrass (S)*	*Short-rotation Ryegrass + White Clover (S + C)*
Final liveweight ewes (lb)	97	125	120	137
Frozen carcass weight (lb)	40·9	59·1	61·2	69·1
Rumen contents weight (lb)	11·74	10·49	8·11	8·12
V.F.A. (mM/100 ml)	11·81	13·40	12·26	14·67

appetite was lowest in those animals grazing perennial ryegrass only and was highest for those on the short-rotation ryegrass plus white clover plots. It is evident that the animals with the slower fermentation rate (namely, those eating perennial ryegrass only) can in part compensate for their lower fermentation rate by having more capacious rumens. In the case of the short-rotation ryegrass plus clover animals, not only will there be more acid produced, but it will have to be absorbed more rapidly from the smaller rumen. Although there is very considerable variation between animals within each group, it has been found that the papillae which pro-

vide the absorption area are in general better developed in the short-rotation ryegrass plus clover animals than in the perennial ryegrass sheep (see Fig. 1).

The individual volatile acids produced in the rumens of animals on the four pasture types have so far been determined only for the perennial ryegrass and the short-rotation ryegrass plus clover groups. It was found that the short-rotation ryegrass plus clover group was significantly lower in acetic and significantly higher in both propionic and butyric acids than the perennial ryegrass group. The relative contribution of the clover and the ryegrasses to this difference still has to be determined. It is evident, however, that the short-rotation rygrass plus clover produces, besides a more intense fermentation in the rumen, a mixture of acids that are more efficient in producing liveweight gain than are those formed from perennial ryegrass.

Discussion

From the results on the relative weight of rumen contents and other evidence obtained in these experiments, it would appear that the physical action of the food on gut distension is not the only factor that regulates appetite. It is highly probable that the concentration of the end products of the fermentation can be the controlling factor under the condition of high fermentation rate in the rumen. In simple-stomached animals it is believed that glucose concentration in the blood acts as the appetite regulator. In sheep and cattle the alteration of sugar concentration in the blood has no influence on appetite, whereas the level of acetic or propionic acid does have. So, presumably, it will depend on which reaches its physiological threshold first—the concentration of acetic or propionic acids, or the physical fill of the rumen—that will determine which has the controlling influence on appetite. From this evidence it appears that there are the same differences between perennial and short-rotation ryegrass as there are between hay and concentrates or long hay and ground hay. Thus, perennial ryegrass behaves as a more fibrous plant, more slowly digested, giving a higher proportion of acetate, while short-rotation ryegrass is more rapidly digested with less of the fermentation products coming from cellulose. Clover, with its low fibre and high soluble carbohydrate, also increases the intensity of the fermentation.

It is hoped now to carry on this research programme and determine which are the particular components of the plant which give rise to a particular rate of fermentation and proportion of fatty acids. The proportion of these components will, of course, vary

with the stage of growth of each particular species. It also seems probable that a particular pasture mixture which is ideal for lamb fattening may not be the ideal one for milk production.

It is hoped that further work along these lines will bring a rational approach to plant breeding and pasture management.

It must not be forgotten that the animal comes into this, and to understand fully the problem of appetite and production of livestock at pasture it is necessary to know why different animals have different liveweight gains on the same pasture. The difference in utilization of the end products of fermentation between animals is a complicated story but there are many aspects of animal differences in regard to the rumen fermentation of feed that can be clarified. Besides being hopeful of improving pasture for particular types of animal production, there would appear to be scope for the breeding and selection of animals for maximum efficiency of conversion of herbage and hence maximum liveweight gains.

In this paper only the basic factor influencing appetite has been dealt with—*i.e.*, the intake of herbage which is not deficient in minerals, and in which toxic substances are not present. In leaving out of consideration other factors which present special effects, such as decreasing "palatability", it is not the writer's wish to give the impression that they are unimportant. They certainly are important and it is hoped to be able to study them in the future.

DISCUSSION

Q:: *Does the stomach lining change as the type of diet changes?*

A:: Yes.

Q:: *Has any study been made of milk production in ewes grazed on these different pasture types?*

A:: Not to date.

Q:: *What is the relationship of these findings to those on bloat?*

A:: The present study is part of the general field of ruminant nutrition.

Q:: *Is this work being extended to species other than ryegrasses?*

A:: The trials are being extended to include long-rotation ryegrass but not to other species at present.

Q:: *Does the proportion of fatty acids liberated into the bloodstream from the rumen influence the distribution of fat in the carcass?*

A:: This may influence the amount of fat but nothing is known about its effect on the fat distribution in the carcass.

THE EFFECTS OF
DIFFERENT PASTURE SPECIES AND VARIETIES
ON SHEEP PRODUCTION

IV: SOME ASPECTS OF THE CHEMICAL COMPOSITION OF PASTURE HERBAGE

G. W. BUTLER and P. J. PETERSON*

THIS PAPER briefly discusses two research topics on which the writers are currently engaged at Plant Chemistry Division, and which both fall within the broad field of plant/animal relationships. These topics are respectively:

(a) The selenium nutrition of ruminants.

(b) Differences within species of ryegrass in the levels of chemical constituents which are of interest from the viewpoint of ruminant nutrition.

Selenium

Wallaceville and Lincoln workers (Drake, Grant and Hartley, 1959; McLean, Thompson and Claxton, 1959; Hartley, Grant and Drake, 1960) have shown that small quantities of selenium given to sheep either orally or intramuscularly lead to beneficial effects in many areas of the country—remission or prevention of white muscle disease, improvements in fertility, and improvements in rate of growth of the animals.

It is obviously important that the various facets of the selenium cycle in New Zealand grasslands should be well understood and a number of research laboratories are at present tackling aspects of the problem which relate to their own particular interests and skills. At Plant Chemistry Division, the uptake and metabolism of selenium by plants and also the form in which selenium is excreted in dung are being examined.

The selenium content of pasture herbage is very low, being of the order of 0·01 to 0·1 parts per million (p.p.m.) dry weight, which is 100 to 1,000 times less than the average content of trace elements such as copper or zinc. Chemical determination of

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selenium in such small amounts presents experimental difficulties which have, however, been overcome by New Zealand workers (Cousins, 1960; Watkinson, 1960). So far, however, it has only been possible to determine chemically the total selenium content of the tissues. This has the limitation that all the selenium determined may not be available to the animal and it is therefore desirable to know the chemical forms of combination of selenium in the plants.

Selenium made radioactive affords a sensitive and convenient method of examining this question. The radioactive material is obtained as sodium selenite of high radioactivity per unit weight of selenium and it can therefore be added to nutrient solutions at levels which are not far removed from the natural conditions in New Zealand and which are certainly well below levels at which toxic effects on plants would be seen as a growth retardation.

Pasture plants were grown in nutrient solutions containing radioactive selenite, in a controlled environment cabinet. After a suitable period had elapsed for the uptake of the radioactive selenium and its assimilation into various compounds, the plants were cut and subjected to chemical fractionation. The distribution of radioactivity in various compounds was then investigated.

Species from three plant groups have been chosen for examination.

(a) *A representative of the selenium accumulators.* These are plants which are capable of absorbing selenium to quite high levels and which grow on seleniferous soils—*i.e.,* soils with a high selenium content. The plant selected was *Neptunia amplexicaulis,* a legume which is restricted to seleniferous soils in central Queensland, and for which selenium levels as high as 4,000 p.p.m. have been found (McCray, private communication). Furthermore, selenium would appear to be beneficial for the growth of this plant, since, when *Neptunia* is grown using highly-purified nutrients, there is a definite growth response to selenium (McCray, private communication).

(b) *A representative of an intermediate group of plants,* which can contain moderate amounts of selenium (up to 50 p.p.m.) without marked toxic symptoms—*e.g.,* wheat. Normally, they do not have a high selenium content, but they can contain moderate amounts when growing in soils with a relatively high selenium content.

(c) *Some pasture species* (containing 0·01 to 0·1 p.p.m. selenium)—white clover, red clover and perennial ryegrass.

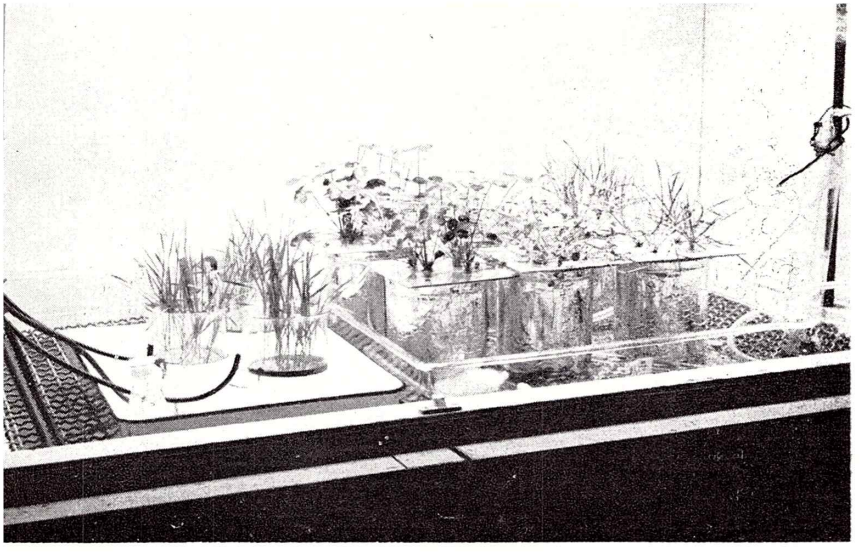

Fig. 1: Plants growing in nutrient solutions containing radioactive selenite in a controlled environment cabinet.

The results obtained from the three groups of plants showed marked differences in the distribution of radioactivity, as shown in Table 1.

TABLE 1: The Percentage of Radioactive Selenium in the Alcohol-soluble, Water-soluble and Residual Fractions of Herbage from Various Plant Species.

	Neptunia	*Wheat*	*Ryegrass*	*White Clover*	*Red Clover*
Alcohol-soluble	92	18	19	28	34
Water-soluble	4	5	3	4	4
Residue	4	77	78	68	62

Whereas with leaves and stems of *Neptunia,* 92 per cent. of the radioactivity can be extracted in boiling aqueous alcohol, with wheat herbage only 18 per cent. of the radioactivity can be extracted in boiling aqueous alcohol and water. With herbage of pasture plants also, a large fraction of the radioactivity is not extracted by aqueous alcohol and water.

With regard to the nature of the extractable radioactivity in the herbage, interesting differences were found between the different species. The most important finding from a nutritional point of view was that most of the radioactivity in the herbage of wheat and pasture plants was found to be bound to the leaf proteins. With the selenium-accumulating plant, on the other hand, only a small fraction of the total selenium was bound to protein. Further, the selenium appeared to be replacing sulphur in the

sulphur amino acids which are important building-blocks of protein.

It may be concluded therefore that, under the conditions of these experiments, for all the plants studied except *Neptunia*, the radioactive selenium in the herbage became predominantly associated with the selenium counterparts of the common sulphur amino acids either in the free state or in the proteins. This is important to know from the point of view of ruminant nutrition, as it would indicate that the availability to the animal of selenium ingested in this form should be investigated. From American literature on selenium toxicity in the Mid-West, it might be expected that this selenium would be readily absorbed, but the matter requires checking under New Zealand grazing conditions. If this should prove to be generally the case, it would mean that the total selenium in herbage could be regarded as being readily available to the animal and hence total analyses for selenium would reflect the nutritional status of the herbage to animals with respect to selenium.

It is also interesting that the amount of radioactive selenium associated with protein in *Neptunia*, the selenium-accumulating plant, should be so low, compared with the other plants examined. The tolerance of this plant to high selenium soils may have something to do with a capacity for discriminating against selenium in the synthesis of protein by this plant.

Excretion of Selenium

During the course of this work, Dr F. B. Cousins of the Otago Dental School advised the writers that there was a high excretion in the dung of selenium given orally to sheep as sodium selenite. When a dose of 5 mg was given, 40 per cent. of the selenium was recovered in the dung in 72 hr. This observation is important, since previous reports of experiments with non-ruminants had indicated a predominantly urinary excretion. It suggests that much selenium, given as selenite, may be rendered unavailable to the animal in the digestive tract.

This observation has been confirmed at a lower dose-level—namely, 20 μg selenium—by the use of radioactive selenite. This is about the amount of selenium which an animal would ingest daily. Fifty per cent. of the administered radioactivity was recovered from the dung of two sheep which were allowed to graze normally after injection of radioactive selenite into the rumen. By similar techniques to those used for the plant fractionation studies, it has been found that:

(a) Less than 10 per cent. of the selenium is soluble in water or organic solvents.

(b) Approximately half the radioactivity is dissolved by enzymes which digest protein.

(c) The remainder is readily soluble in bromine-water and is apparently present in an insoluble inorganic form.

Because of the relatively large amount of selenium which is excreted in the dung when animals are dosed orally with selenite, it appeared desirable to examine the availability to plants of the selenium present in the dung from selenium-dosed animals. This has been examined by growing perennial ryegrass in pots in mixtures of sand and powdered radioactive dung. The results are shown in Table 2 from which it will be seen that very little of the total radioactive selenium in the dung had been taken up into the herbage. The roots had grown throughout the pots at the end of the experiment.

TABLE 2: The Percentage of Radioactive Selenium found in the Herbage of Perennial Ryegrass Plants Grown on Mixtures of Radioactive Selenium Containing Dung and Sand.

Amount of dung per pot	*Per cent. Radioactive Selenium in Herbage*	
	First Cutting	*Second Cutting*
10 g	0·08	0·19
	0·37	0·18
20 g	0·07	0·14
	0·06	0·09
30 g	0·02	0·09
	0·09	0·06

Field conditions were not simulated in this experiment; the dung was intimately mixed with sand to give the roots the maximum opportunity to absorb the selenium if it were readily available. Since such a small fraction of the selenium was taken up under these conditions, it would appear likely that the uptake of selenium into the herbage of pasture plants from dung under field conditions would be a slow and probably negligible process.

Variations in Chemical Composition within Ryegrass Varieties

In the breeding of herbage plants, one of the principal aims should be to develop improved varieties which are not only pro-

ductive (in terms of yield per acre per annum, or seasonal yield), but also of optimum chemical composition from the viewpoint of ruminant metabolism. For pasture species which are the subject of intensive selective breeding programmes, it is therefore desirable to assess the extent of genetic variation in various chemical constituents which are considered to have nutritional significance.

Some experiments along these lines have been carried out at Plant Chemistry and Grassland Divisions with the ryegrasses. Iodine was the first chemical constituent to be examined. It was found that thirteen perennial ryegrass plants taken at random gave iodine contents ranging from 18·5 to 247·0 μg per 100 g dry weight. Similarly, the iodine contents of seven short-rotation ryegrass plants ranged from 7·5 to 57·5 μg per 100 g dry weight. Analyses of plants derived from crosses of four of the perennial ryegrass plants were made and it was shown that the percentage iodine content of the herbage was an inherited characteristic (Fig. 2).

A more extensive experiment has recently been completed, in which seven plants derived by hybridization from perennial and short-rotation ryegrasses have been examined for herbage contents of a number of mineral constituents (in collaboration with Dr P. C. Barclay, Grasslands Division). The plants were laid out as clones randomly so that variations due to soil and environment could be allowed for.

It was found that nitrate levels varied up to ten-fold among the seven plants. Smaller variations (up to three-fold) were found for sodium, potassium, calcium, manganese, aluminium, copper, titanium, iron, zinc, sulphate, and acid-soluble phosphorus. Some interesting interactions were found between the levels of a number of the mineral constituents.

Growth of these plants was also determined at (or near) times of cutting of herbage for analysis. It is interesting to note that in no case so far has variation in a particular plant constituent been correlated with differences in herbage production of the plants. This emphasizes the point that the assessment of the nutritive value of plants being used in the development of new strains requires detailed chemical servicing.

Variations in the levels of the alkaloid perloline were also examined. Alkaloids are generally poisonous to animals, so perloline is of interest from the point of view of ruminant nutrition (Cunningham and Clare, 1943). Perloline levels varied up to 50-fold amongst perennial ryegrass plants; with the seven plants used in

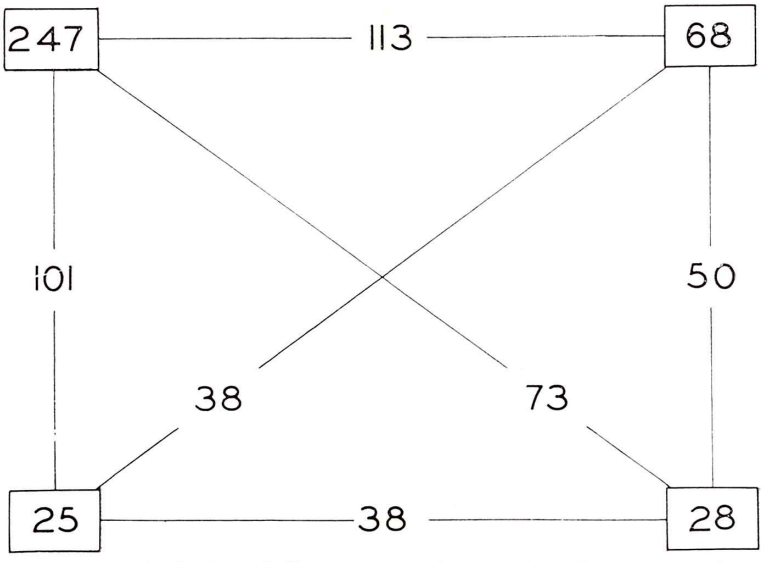

Fig. 2: Data for herbage iodine contents of crosses from four parent plants. Values for parents are shown at the corners of the diagram and the values for the crosses are the means for 20 plants from each cross. The figures represent micrograms of iodine per 100 grams dry weight.

the preceding experiment the values ranged from 8 to 264 mg perloline per 100 g dry weight.

To sum up, differences between plants in herbage levels of nitrate, iodine and perloline are large in the ryegrasses, and smaller differences occur for a number of other mineral constituents. Differences in iodine content have been shown to be inherited and there is a small amount of evidence that differences in perloline levels are also inherited. This still needs to be tested for the various mineral constituents mentioned above.

Previous papers in this symposium have described the surprisingly large differences in animal production which can occur when sheep are set-stocked on perennial and short-rotation ryegrass pastures. The differences in chemical composition of the two ryegrasses are ultimately at the bottom of this, and it will be obvious that a long-term programme aimed at elucidating the manner in which this chemical composition is genetically controlled could conceivably lead to the development of varieties which are still better nutritionally than those available today. It is also clear that the work should be extended to include other chemical constituents and also other pasture species.

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DISCUSSION

Q:: *Was nitrate at a dangerous level in any of the grasses studied?*

A:: Yes. In two of the plants, herbage nitrate rose well above the level of 1·5 per cent. KNO_3 equivalent, which is regarded as the level above which there is a risk of toxicity.

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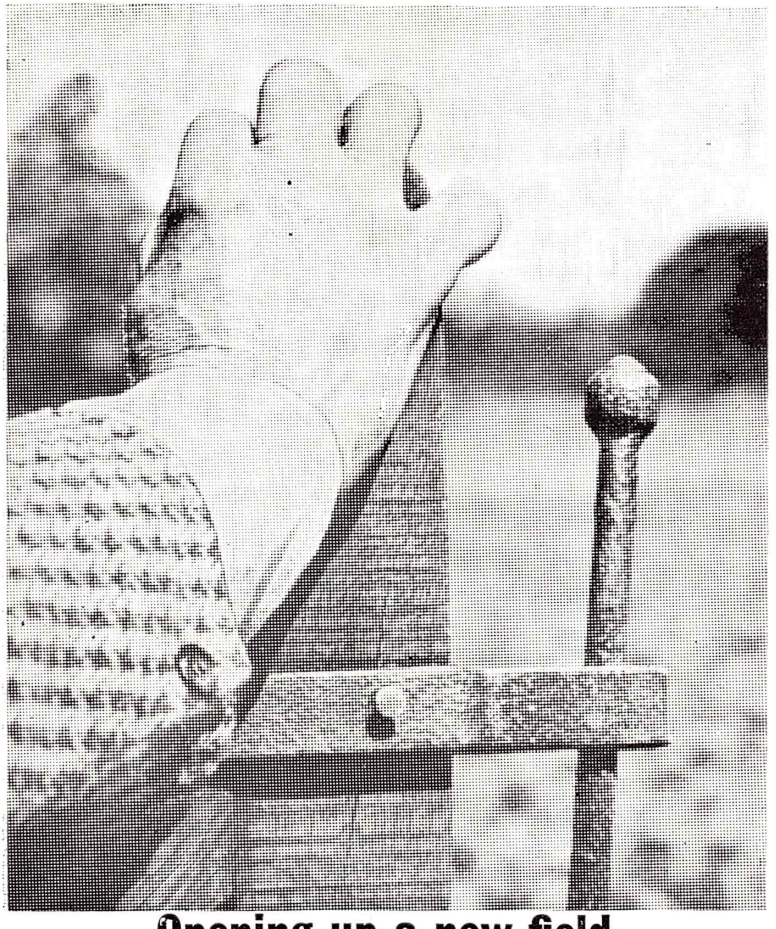

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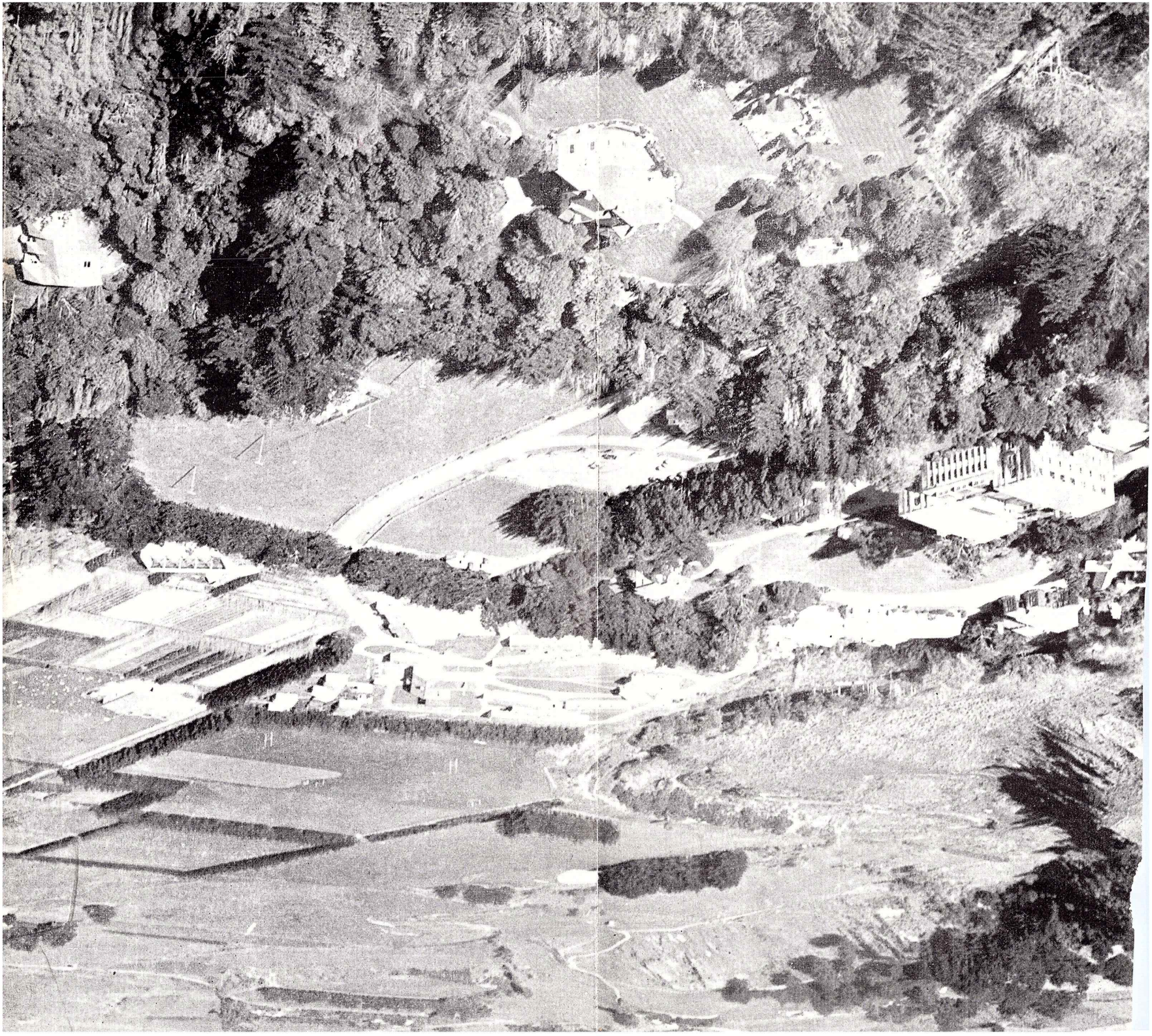

FRONTISPIECE:

An aerial view of the College buildings and surroundings.

The Main Building is seen left of centre. Across the campus and also at top centre are the Hostels. Towards the right are the Horticultural plots with the glasshouses opposite on the left of the roadway. Towards top right is the Machinery Hall with the Field Husbandry plots beyond it, at centre right the Wool Department, and at lower right the Veterinary Clinic. At bottom centre is "Wharerata," which houses the Sheep Husbandry, Economics and Horticulture Departments.

Postal Address:

MASSEY COLLEGE P.O., PALMERSTON NORTH, NEW ZEALAND.

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